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The comparative efficacy of overt and non-overt practice responses in programed instruction was investigated under a variety of practice and test conditions using a paired associate learning task. Proponents of operant learning models have consistently questioned the relative effectiveness of passive viewing in programed instruction. An alternative position maintains that programed learning primarily involves the selection of responses from well established repertoires. Overt practice responses under such conditions are redundant if not disruptive. Differential practice effects were considered in a series of experiments requiring the association of keyboard responses to single letter stimulus displays presented on a viewing console. Overt practice responses were found to have an essentially neutral effect upon paired associate learning. An interference effect was noted when the temporal interval between successive stimuli was minimal. The extension of unfilled interstimulus and intertrial intervals was found to have a strong positive effect on response acquisition and to warrant further parametric research. Non-overt practice effects were discussed in terms of existent contiguity and hypothesis selection theories none of which adequately accounted for all the findings. (SS)

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FINAL REPORT

Project No. 1016
Grant No. 7-24-0210-198

EFFECTIVENESS OF THE OBSERVING RESPONSE WITH PROGRAMED PICTORIAL STIMULI

As a Function of Interstimulus Interval, Overtness and Correctness of Response

HARVEY B. BLACK, Project Director

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Bloomington, Indiana 47401

March 1968

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EFFECTIVENESS OF THE OBSERVING RESPONSE WITH PROGRAMED PICTORIAL STIMULI

As a Function of Interstimulus Interval, Overtness and Correctness of Response

Introduction

Instructional procedures that include presentation of films, television, lecture and demonstration usually require only viewing behavior by the learner during presentation. Proponents of "learning by doing" methodologies have steadily challenged the relative effectiveness of mere passive viewing (Skinner, 1960). If active responding contributes either directly or indirectly then it would seem to follow that the teaching effectiveness of instructional procedures that traditionally have required only viewing responses during practice might be materially increased by requiring active, overt practice of criterion responses during the course of instruction.

Evidence of effects associated with adding overt practice requirements has been assembled and reviewed by Allen, (1960) Lumsdaine, (1964) Travers, (1964) Holland, (1965) and May (1966). However, each of these reviewers have noted that the findings leave basic questions unanswered. For example, Travers observed that "not much is known about the kinds of activity that result in effective retention and transfer" (1964, p. 18). Lumsdaine stated that "the most productive orientation for research on instructional media is to look for ways in which responses of the student, overt and implicit, can be controlled by stimulus conditions" (1964, p. 587). Thus, existing research has generally prompted the conclusions that it remains to be determined what kind of activity, overt or implicit, is associated with most effective learning and how these kinds of activity can be controlled by stimulus conditions.

The producer or utilizer of instructional procedures or devices finds little in the research literature to help him decide how much and what kind of practice might be optimal for achieving any given objective. Consequently, the type of practice imposed upon the learner is often resolved in the practical situation by providing for the least demanding practice mode available which is usually assumed to be the postulated implicit responding by the audience during the presentation of instructional sequences. In other cases either theory or tradition may dictate other response modes as in the case of required active, overt practice associated with certain programed materials, laboratory tasks or workbooks.

One attempt to provide a rationale with respect to practice mode that might guide both research and practice has been made by Holland (1965). He argues that overt practice responses may be expected to facilitate learning only when certain specified conditions are satisfied. He proposes as prerequisite conditions an extended learning task, sequential programing that reduces the frequency of practice errors to a minimum, and prompting procedures that do not preclude appropriate precursory behavior which results in appropriate discrimination responses with respect to the primary stimulus. Thus, these proposed conditions for learning require (1) the presentation of discriminative stimuli which must be the occasion for appropriate non-overt discrimination behavior and (2) correct practice responses which must occur either overtly or non-overtly and (3) be subsequently reinforced. The effect of a required overt practice response is to ensure that appropriate precursory behavior and covert emission of correct responses occur. As long as both classes of responses occur covertly, overt practice responses are not required and in short learning tasks are usually not required to maintain relevant covert responses. Given these assumptions regarding the effects of practice mode, the challenge for the programer is to provide programing sequences and prompts which ensure correct practice responses but are not so arranged as to allow the learner to avoid the required discrimination responses.

These two requirements are frequently incompatible in [illegible] that procedures that increase the probability of one reduce the probability of the other. Thus, demanding requirements for discrimination of a given stimulus from the set is met by omitting sequential and other prompts and presenting items in an arbitrarily determined order as they might appear in a test with resulting high incidence of practice errors. The effect of such a relatively unprompted practice arrangement when compared with massed sequencing of identical items with possibility of short-term memory cues has been shown to be facilitating under certain conditions (Suppes & Ginsberg, 1962; Rothkopf & Coke, 1963). On the other hand, highly prompted procedures discussed by Holland (1965) ensure low practice error rates but reduce the probability of appropriate discrimination responses associated with the primary stimulus. Innovative procedures may be discovered which include both desired properties. For example, Faust and Anderson (1967) have demonstrated the effectiveness of a prompting procedure which maintains a relatively low practice error rate while requiring an appropriate discrimination response.

The Holland position then does not require overt practice but does require either overt or non-overt production of the correct practice response following an appropriate discrimination response. An alternative position holds that the correct practice response is not required and is, in fact, redundant if not disruptive in any case in which response learning is minimal. It is argued that learning consists of the selection of hypotheses and that in the mature organism the required responses are typically already well established in the repertoire of the organism. In the theoretical formulation presented by Restle (1962) the occurrence of a reinforced practice response terminates the hypothesis sampling process while the occurrence of a non-reinforced practice response is followed by further sampling. Thus, learning is assumed to occur only on trials during which an incorrect practice response occurs. If this were generally true, it would follow that procedures introduced to ensure the production of reinforced criterion responses, overt or covert, during practice without due regard to hypothesis selection behavior would be at best irrelevant to instruction and that attention might more usefully be directed to procedures that affect the occurrence and efficiency of hypothesis selection behavior. Although the positions seem to differ unambiguously with respect to the need for emitting a correct response during practice it has proven to be difficult to obtain relevant evidence regarding the relative validity of such claims (Estes, 1964). As Lumsdaine (1964) has pointed out, responses, either overt or covert, may not be directly controlled experimentally in the way stimulus factors may be. Thus, following an overt error, S may emit a covert correction response. Suppes & Ginsberg (1962) cite evidence supporting the assumption that young children typically do not make covert correction responses, while adults apparently do. S may refrain from responding, make extraneous responses and otherwise vary from responses expected as a function of instructions or other procedures. In spite of such difficulties in control, the practical and theoretical importance of response mode as a factor in learning has prompted this series of studies that attempt to identify the independent effects of overt practice in paired associate learning.

It was the purpose of the following series of experiments to determine the independent effects of response mode, interval length, information regarding response term preceding (prompt) and following (confirmation) practice response, differential contingencies associated with errors and correct responses and other variables that might interact with practice mode.

General Experimental Plan

In planning research strategies, for an extended series of experiments, certain tactical decisions are required. In order to test the primary assumption that a large number of factors had been confounded with practice mode in earlier experiments, it was decided that all experiments would consist of experimental manipulations in the context of a single task.

Restriction of the range of tasks considered would obviously reduce the generalizability of results to a variety of tasks but the restriction would make possible a more intensive analysis and comparison of a wide range of variables that affect performance of a single task.

The task chosen had to meet the further criterion of being readily subject to the class of controls such as intratrial manipulation of intervals, response mode, information display and response contingencies. An additional consideration was that the task would involve responses sufficiently complex and novel so that some response learning might be reasonably assumed to occur. For example, simple binary responses such as occur in probability learning or concept identification or emission of common words or syllables seem to involve a minimal motor or response learning component (Estes, 1964; Underwood, 1963) and have not been shown to be associated with response mode effects while relatively more complex and unfamiliar responses have (Williams, 1964; Underwood, 1964).

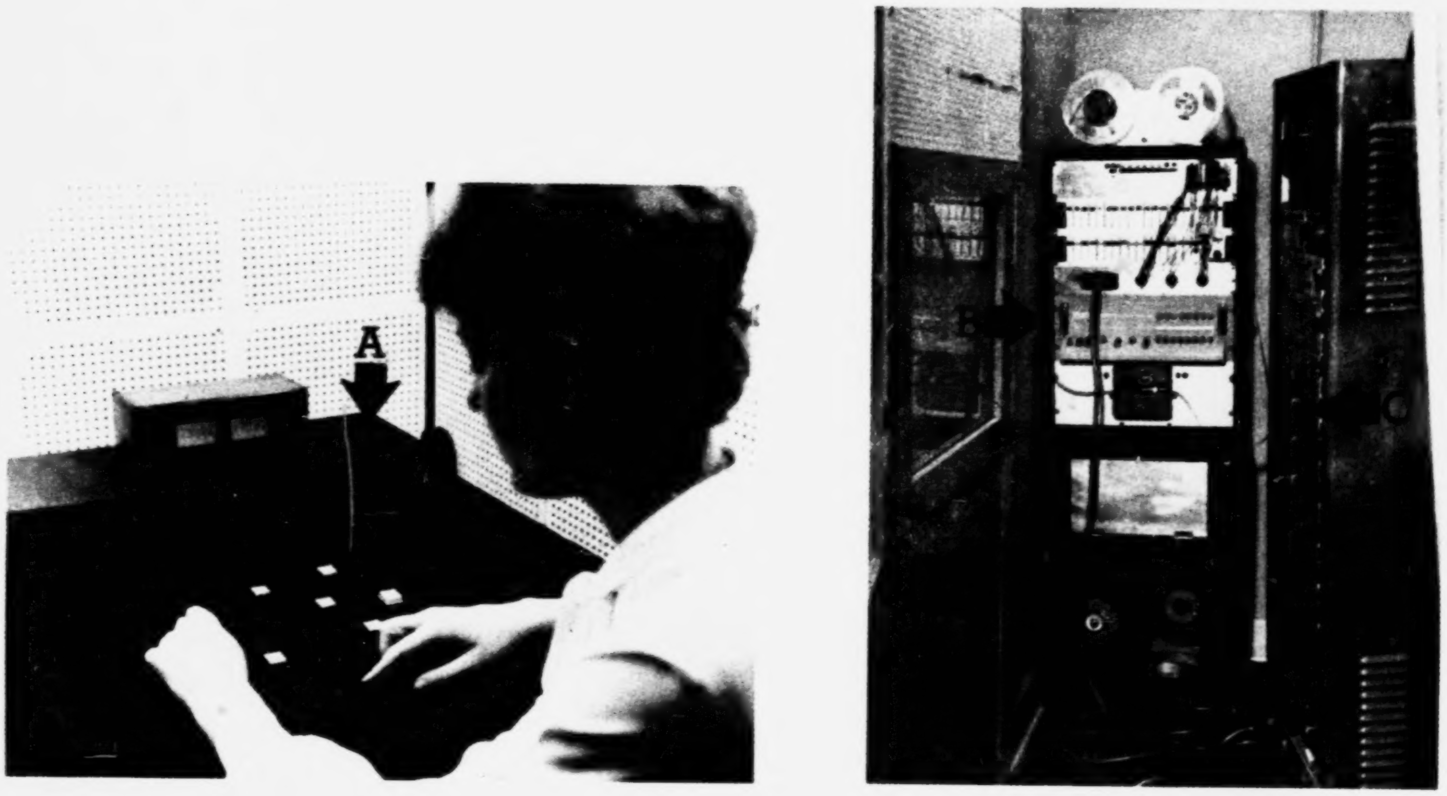
A third consideration was that the task be drawn from some class of tasks that is representative of those found in school learning situations. Although opinions differ widely with respect to the relevance of the paired associate learning paradigm to any significant aspect of school learning (Holland, 1965; Gagné, 1965; Underwood, 1959) it was decided to employ the paired associate paradigm in this series of tasks. Since the primary interest was upon the effects of response mode, it was decided to employ highly meaningful and readily discriminable stimulus term elements which in these studies consisted of selected letters of the alphabet. The response term elements were subsets of three keys selected from a set of seven keys. The arrangement of both the set and subsets was such as to minimize ready association to other displays. Previous research employing an analogous response term display (Cook & Spitzer, 1960) had provided evidence that this class of response terms imposed considerable response term learning requirements upon the paired associate learning task. The requirement of experimental control was satisfied in large part by employing auxiliary electronic display, control and recording apparatus. (Fig. 1).

UNFILLED INTERSTIMULUS INTERVALS EFFECTS

Experiments I and II

In a variety of instructional contexts the members of a pair of items to be associated are presented in serial order.

● Laboratory 1. Informational Factors

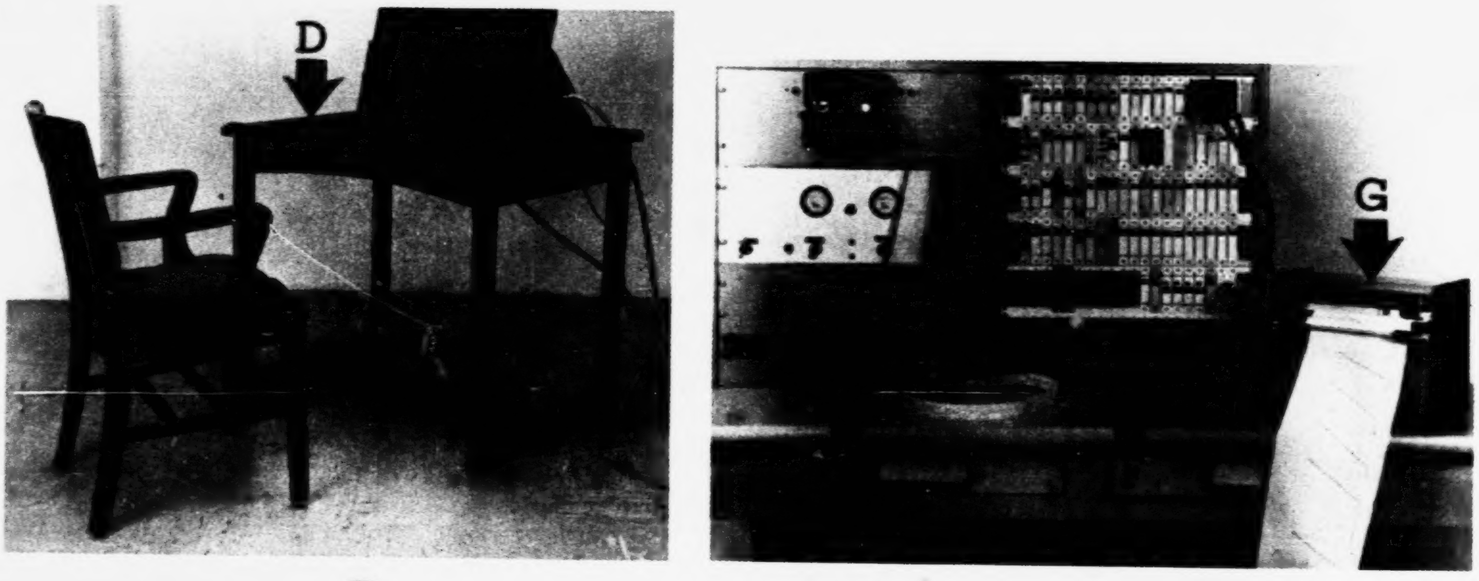


A
RESPONSE CONSOLE

B
PUNCHED TAPE CONTROL AND RECORDING

C
LOGIC CONTROL CIRCUITRY

● Laboratory 2. Motivational Factors



D
RESPONSE CONSOLE

E-F
LOGIC CONTROL CIRCUITRY

G
CUMULATIVE RECORDER

Fig. 1. Laboratory apparatus configuration

The members of a given pair and the successive pairs may be separated by time intervals of varying length. In the context of paired associate learning it has been demonstrated that manipulation of these time intervals affects learning (Nodine, 1963). If the first member of a pair of items is called the stimulus term (ST) and the second member the response term (RT) then the interval between onset of ST and onset of RT may be conveniently referred to as the PRE RT interval and the interval following onset of RT and preceding the onset of the next ST may be identified as the POST RT. An additional event that occurs during the PRE RT in the traditional anticipation training procedure is an overt practice response. In the correction procedure of training an overt response also occurs following RT during the POST RT interval. Thus, the duration of each of the stimulus events, the response events and unfilled intervals separating them may all vary independently. However, if the total inter-trial interval (ITI) is held constant, as it has been in a number of experiments (Cook & Spitzer, 1960; Saltzman, 1951) then manipulation of one of the intra-trial intervals results in corresponding confounded variation in another intra-trial interval making difficult the separation of interstimulus and inter-trial interval effects. These temporal relationships are illustrated in Fig. 2.

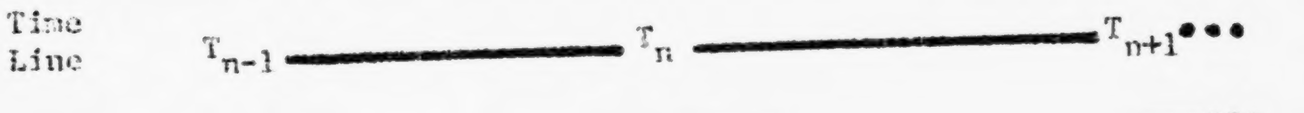

Time Line
T_{n-1}
T_n
T_{n+1}
Stimulus Term
ST_{n-1}
ST_n
Response Term
RT_{n-1}
RT_n
Anticipation Response
R_{1a}
R_{2a}
Correction Response
R_{1c}
R_{1c}
PRE RT_{n-1}
POST RT_{n-1}
PRE RT_n
POST RT_n
ITI_{n-1}
ITI_n

Fig. 2 Time line representation of stimulus, response and unfilled interval events in a representative paired associate task.

The overt response event may interfere with associations between stimulus events (Cook & Spitzer, 1960; Stolurow & Lippert, 1964). If the procedure is S paced the required overt practice response may also delay attainment of criterion performance level (May, 1966). On the other hand, it has been demonstrated in a programed instruction context that overt practice is facilitating when the response term is relatively complex and unfamiliar (Williams, 1964) and when its emission requires associated discrimination responses that may not otherwise occur (Faust & Anderson, 1967).

If overt production of wrong responses interferes with learning (Skinner, 1960; Holland, 1965) while correction responses, overt or covert, (Suppes & Ginsberg, 1962; Bourne & Restle, 1959) facilitate learning then it would seem that an efficient procedure might be that of omitting unprompted overt or non-overt anticipation responses and allowing time for correction responses to occur during the POST RT interval. This might be done by reducing the PRE RT interval and by instructing S not to practice overtly. The effects of extending the PRE RT interval during non-overt practice trials are difficult to anticipate. Reducing the interval may have a facilitating effect by increasing the continuity of the stimulus items (Stolurow & Lippert, 1964) and reducing the probability of the occurance of an implicit incorrect response. On the other hand, lengthening the interval may allow S time to emit a correct implicit anticipation response that is weakly associated and has a longer latency. If, however, learning occurs primarily during (Estes, 1964) or following (Restle, 1962) the presentation of RT, then moderate variation in the duration of the PRE RT interval would be expected to have little effect.

It was the purpose of the first two studies in the series to determine the effects on acquisition of paired associates of independently manipulating the PRE RT and POST RT intervals during practice trials.

Method

Subjects -- In Exp. I Ss were 18 adult volunteers obtained from the Audio Visual Center staff. In Exp. II the 43 Ss were students from Indiana University Education Department, that participated as part of a course requirement. In both experiments Ss were assigned to the experimental conditions according to a randomized procedure. In Exp. II data from all Ss whose first language was not English were discarded since presumptive evidence of failure to follow instructions in Exp. I by these Ss was noted. In addition to data from four Ss being rejected for this reason, data from another three were discarded due to equipment failures resulting in a total of 36 Ss in Exp. II.

Stimuli -- The set of stimulus terms (ST) consisted of the letters Z, Y, F, E, R and L with a projected height of 1 in. They were displayed for 2 sec. on each trial. The ST display was mounted vertically on the response console (Appendix A, Part 1) at the rear edge of a 15½ in. x 35½ in. response panel that was inclined 15 degrees toward the rear. The response term display consisted of subsets of three lighted keys from the set of seven keys that constituted the response key panel (Appendix A, Part 2). The keys were lighted for 1 sec. on each practice trial and were not lighted on test trials. The seven keys were arranged in a 12 in. x 18 in. area on the response panel such that no three formed a straight line and were spatially arranged similarly to the response matrix used by Cook & Spitzer (1960) (Fig. 3).

Apparatus -- The stimulus display was presented by an Industrial Electronics Engineer's 10ooo READOUT unit which permitted random electronic access to any stimulus letter. A relay system (Appendix A, Part 3) (A, D, G) together with additional transistorized logic controls (C, F, E) was used to permit control of time intervals, stimulus sequence control and evaluation and recording of responses on the five pen event recorder. The floor plan showing the arrangement of the apparatus is shown in Appendix A, Part 4.

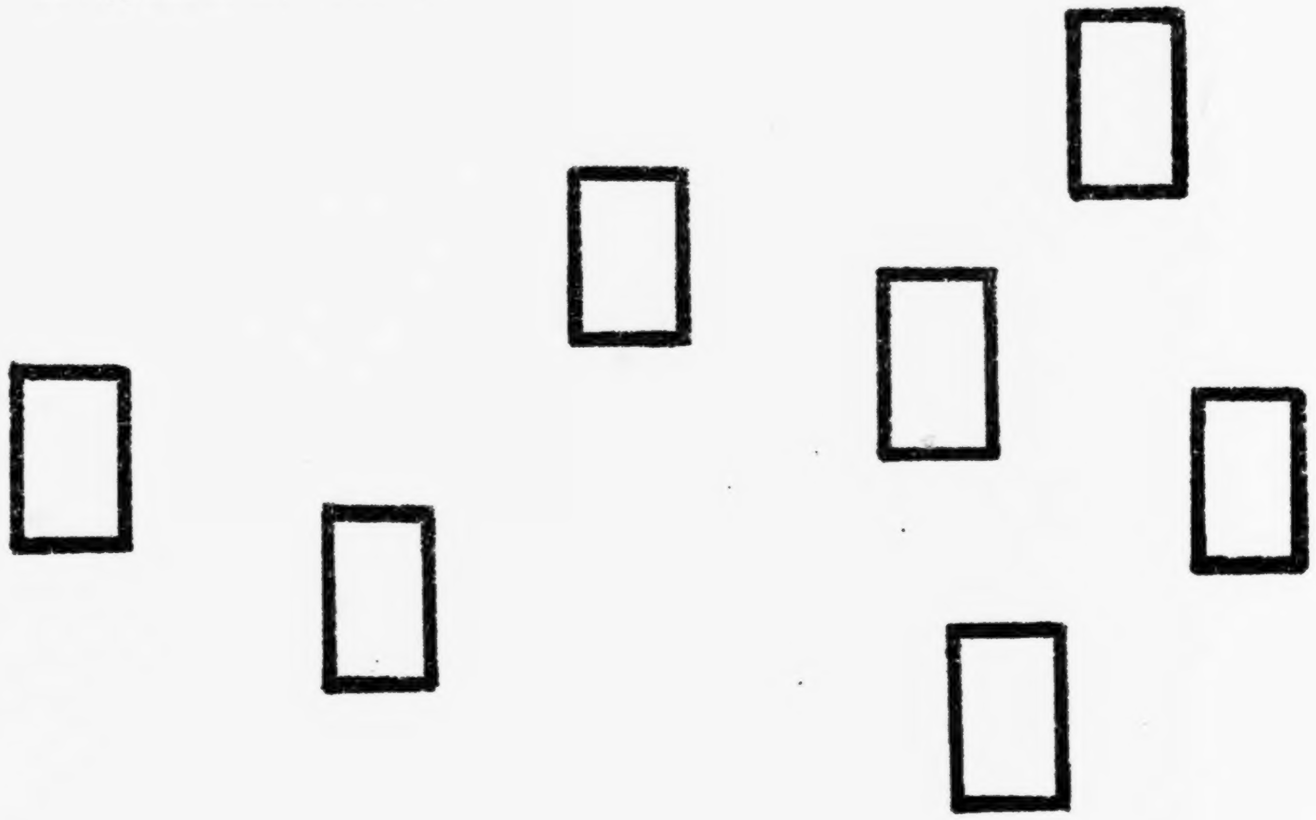


Fig. 3. Array of seven response buttons (after Cook & Spitzer, 1960)

Procedure -- *S* was seated at the response console (Appendix A, Part 5; Photo labeled Fig. a) and instructed that he was to "observe only" during training trials and was to press the keys he thought were correct during the time that the red backlight accompanied a letter on the stimulus display screen. Two training trials each including a random permutation of the six letter-pattern pairs were followed by a test trial indicated by the red backlight. The alternating training trials and test trial continued until *S* attained two consecutive errorless test trials. The test trials provided a 5 sec. interval for responding following a 2 sec. display of the ST. The red backlight disk signaling that an overt response was required remained on during the ST and for an additional 4 sec.

Design -- The experimental design for both experiments consisted of a 3 x 3 factorial design with three PRE RT and three POST RT intervals. The PRE RT intervals were 0, 4 and 8 sec. and the POST RT intervals were 1, 5 and 9 sec. These specific values were chosen to facilitate comparison with the Bourne & Bunderson concept identification data (1963).

Results

Total errors on test trials were summarized (Appendix A, Parts 6 & 7) for both experiments. In both experiments the POST RT intervals differed significantly with errors decreasing as a function of increased interval: Exp. I; $F(2, 9) = 7.01$, $p < .05$, and Exp. II; $F(2, 27) = 27.89$, $p < .01$. In neither experiment did the PRE RT means differ significantly. However, in Exp. I there was a significant interaction between PRE and POST RT, $F(4, 9) = 6.32$, $p < .05$. Exp. II was designed to make a more powerful test of the interaction by increasing the number of replications and reducing error variance by eliminating *Ss* whose first language was not English since these *Ss* in Exp. I seemed to have great difficulty in following directions on early trials. In Exp. II the PRE RT by POST RT interaction was not significant.

Discussion

The significant effect of extended POST RT interval upon reduction of practice errors is consistent with the findings in concept identification tasks (Bourne & Bunderson, 1963), motor learning (Weinberg, Guy and Tupper, 1964) and paired associate learning (Nodine, 1963). In each of these cases the intervals tested were of short duration, averaging 5 sec. Evidence that longer intervals may be interfering in simple motor learning (Bilodeau & Bilodeau, 1958) and concept identification (Bourne, Guy, Dodd and Justesen, 1965) have been interpreted as indicating that forgetting of the stimulus events may occur over more protracted delays.

The absence of a significant effect associated with extending the unfilled PRE RT interval is consistent with the observed effects of manipulation of the interval between the anticipation response and the information feedback (PRE IF) event in a variety of human learning contexts. In paired associate learning (Battig & Brackett, 1963; and Kintsch & McCoy, 1964) concept identification (Bourne & Bunderson, 1963), selective learning (Noble & Alcock, 1958) and simple motor learning (Bilodeau & Bilodeau, 1958) which included controls for POST RT and ITI there were no effects associated with delay of IF. It should be noted that PRE RT in the present study can not be simply equated with the PRE If intervals of the above studies since no overt response was required in the present study. In the present study Ss were asked to observe during PRE RT and no instructions were given regarding any additional overt or implicit practice responses. Thus, the time following the presentation of the stimulus and the occurrence of the response and the duration of the overt response preceded the PRE IF interval in other previous studies cited and no analogous events occurred in this study. The additional effect of these events upon the association of ST and RT is assumed by Cook & Spitzer (1960) to be interfering by reason of their disrupting the contiguous relationship of the two terms to be associated. These effects could not be evaluated in this experiment.

Two other experiments may be cited to suggest that while the PRE IF interval has been found generally to have little or no effect upon a variety of human learning tasks it may have effects in some situations. In a verbal maze task Saltzman (1951) found that increased delay was associated with interference. Attempts to replicate his results by Jones & Bourne (1964) were unsuccessful but the latter speculate that instructions may have differed in that Saltzman reports a tendency on the part of his Ss to overtly rehearse irrelevant aspects of the stimulus display while no similar tendency was noted by Jones and Bourne. If the PRE IF interval is filled with irrelevant practice it may have the effect of interfering with the short term retention of the stimulus term (Peterson, 1959).

In a paired associate experiment employing difficult to pronounce and low frequency trigrams for both ST and RT's (Jones & Bourne, 1964) found that increased duration of PRE RT had a facilitating effect upon acquisition. In a previous study it was shown that extending the PRE RT interval was facilitating for paired associate learning involving highly confusable stimulus terms but less so with readily discriminable stimulus terms (Black, 1967). In the present study the stimulus terms were readily discriminable and familiar.

If efficiency is measured in terms of total time required to reach criterion (Bugelski, 1962) it must be noted that the inverse function between length of POST RT and number of trials to criterion results in an approximately equal total acquisition time for all practice conditions with PRE RT held constant. However, the increased number of practice errors associated with the shortened POST RT condition may have effects upon retention that could not be determined in this experiment.

Efficiency may be improved in terms of time to criterion by reducing the PRE RT interval since in this experiment no differences in performance were associated with such a manipulation. However, if the stimulus terms were relatively more difficult it is not clear what effect a reduction of the PRE RT interval would have.

VARIATION IN FILLED AND UNFILLED PRE & POST INTERVALS

Experiments III, IV and V

The purpose of Experiments III, IV and V was to determine the effects of varying the overtness of practice in paired associate learning that involved considerable response term learning. Underwood (1963) has noted that motor factors in paired associate learning typically have negligable effect upon learning except in the cases in which response learning is a dominant factor. Cook & Spitzer employed a paired associate task in which considerable response learning seemed required since the responses were novel geometric pattern reproductions (1960). They found that the overt anticipation practice response was associated with more errors than a corresponding non-overt practice condition and suggested that interference may have been a function of a disrupting effect of the overt practice response upon the association of implicit responses to the stimulus and response terms. They also suggested that the temporal separation of the stimulus and response terms that is required by the interpolation of a practice interval in the anticipation procedure may provide additional interference.

In Exps. III, IV and V the PRE RT intervals required for (1) executing the anticipation response and (2) the interval between the response and the presentation of the response term (POST RT) were manipulated independently.

In order to investigate the effects of overt practice under varying conditions of interstimulus intervals in paired associate learning involving complex motor responses, the present studies were designed such that overtness of practice, duration of PRE RT and the duration of POST RT were varied independently.

Method

Apparatus and Stimuli -- The apparatus and simuli were identical with those used in Exps. I and II. One additional lighted switch similar to those used in the response panel and referred to as the practice key in the S-OV instructions was mounted 4.5 in. to the right of the rear view screen and was wired so that is displayed a green light whenever the stimulus letter appeared with a green background.

Procedure -- Ss were initially instructed that "all he had to do was to notice which pattern of lighted keys below followed each letter". He was then shown the six stimulus (ST) response term (RT) pairs and asked to observe only and not press the keys. ST and RT were exposed for 1 sec. each with either 0 or 4 sec. interval between ST and RT (PRE RT interval) and either a 1 or 5 sec. interval between RT and the next ST (POST RT interval), depending upon which of the four interval combinations they assigned.

Ss were then assigned to one of three practice conditions. The overt practice (OV) group was instructed that immediately after each stimulus letter with a green backlight was presented they were to "press the three keys that they thought followed it". The semi-overt practice group (S-OV) was told that they were to "press the green practice key" to the right of the real view screen three times as they thought of the three correct response keys. The non-overt (N-OV) practice group was told that they were to "try to guess which three keys followed the letter" and that they were not to press any keys during practice.

S was then presented the next set of ST-RT pairs and practiced according to the instructions given to the group to which he had been assigned. The test procedure was then described to all Ss who were then told that whenever the letter appeared against a red background light they were to press the three keys that followed that letter. During the test cycles the RT was not presented. A 5 sec. unfilled interval separated each completed test trial response and the succeeding ST.

In the OV and S-OV practice conditions and for all Ss in the test trials S was given an S-determined response interval. Immediately following the completed overt practice response of the OV and S-OV groups and following the 1 sec. display of ST for the N-OV group an additional 0 or 4 sec. PRE RT interval preceded the onset of RT.

Ss then completed the first test cycle and alternated between two practice and one test cycle until they had completed two consecutive test cycles without error.

Subjects -- Ss were 26 students in a graduate education course who participated as part of course requirements. Data from 2 Ss were discarded because of procedural errors. Two Ss were assigned to each of the 12 independent groups resulting from factorial combination of two PRE RT intervals, two POST RT intervals and three practice conditions.

Results

Errors on test cycles were totaled for each S. Mean errors were summarized in the tables found in Appendix B, Part 1. The shorter POST RT intervals was associated with increased errors, F (1, 12) = 10.37, p < .01. The difference between POST RT groups was most marked when combined with the 0 se PRE RT, F (1, 12) = 8.95, p < .05. This interaction is illustrated in Fig. 4. No other main effect or interaction was significant.

Experiment IV

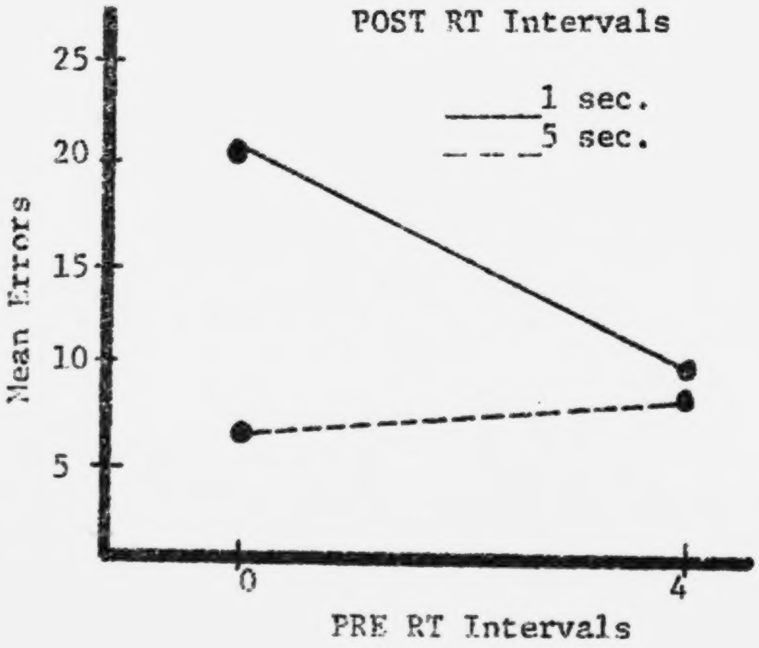


Fig. 4. Mean errors for 1 and 5 sec. POST RT conditions as a function of PRE RT interval.

The data in Exp. III supported earlier findings of the facilitating effect of increasing POST RT intervals within the ranges tested in this experiment. Failure to find differences associated with practice mode, as had been reported by Cook & Spitzer when using very similar procedures (1960), led to a consideration of a possible confounding of the practice variable since all groups performed overtly on the interpolated test trials. Estes, Hopkins and Crothers (1960), Greeno (1962) and others have found that under certain circumstances Ss may systematically modify responses over a series of non-reinforced test trials. Test trial responses on early trials are especially likely to be incorrect responses and Skinner (1960), Holland (1965) and Cook & Spitzer (1960) indicate that overt practice of incorrect responses is particularly interfering. In order to reduce possible confounding attributable to overt responses on test trials it was decided to delay the first test trial until after the completion of the second practice cycle. Delaying longer was not attempted since an appreciable number of Ss in Exp. III were achieving errorless performance by the third trial. Thus, Exp. IV was undertaken to modify Exp. III by providing additional practice trials prior to the first test trial in order to determine whether the modified procedure would be more sensitive to practice mode differences.

Method

The 24 Ss were from a grduate education course and participated in the experiment as part of course requirements. All treatments and procedures were identical with those in Exp. III except that in contrast to the single presentation of the list of pairs prior to the first test trial all groups in Exp. II were presented with three successive presentations of the list of pairs and then given alternating test and practice trials until reaching criterion as in Exp. III. Ss practiced according to the instructions on each practice trial following the first presentation of the list during the instructions.

Results

Total errors during test trials were summarized. Mean and analysis of variance summary are reported in Appendix C. The data in general resemble those found in Exp. III. Extending the POST RT interval was again found to be facilitating $F(1, 12) = 6.40$, $p < .05$. As in the earlier experiments PRE RT was not a significant factor. None of the other interactions were significant except the interaction between PRE RT x POST RT x response mode. Inspection of the raw data suggested the possibility that this effect may have been spuriously inflated by the unusually high error rate of one S whose first language was not English and may not have correctly understood the instructions.

Experiment V

Although the main effects in Experiment IV were consistent with those of Exp. III the interaction effects in the two experiments differed. Delaying the first test trial until additional practice trials had occurred in Exp. IV was associated with the occurrence of a significant three way interaction involving the practice mode. In order to further reduce possible interaction between the overt nature of responses in test trials and the response mode of practice trials it was decided to postpone the occurrence of the first test trial until after five practice trials had been completed. The possibility that Ss whose first language was not English might respond differently than others was suggested in both Exp. I and Exp. IV, so it was decided to separate language groups by assigning them to independent blocks. The relatively low power of the tests in Exps. III and IV associated with the small sample of subjects seemed to be another possible weakness in design. Consequently it was decided to increase the number of replications in Exp. V.

The purpose of Exp. V was to modify the procedures of Exp. IV with respect to number of pre-test practice trials, number of experimental replications and assignment of Ss to experimental blocks by first language, in order to further test the effects of manipulation of response mode.

Method

A total of 96 Ss from two first year graduate courses in education participated as part of course requirements. Ss were randomly assigned to the twelve experimental conditions described in Exp. III such that there were 8 Ss per condition. One of the eight replications consisted of Ss whose first language was not English. Instructions were presented by tape recording and by remotely presenting a sample stimulus consisting of the letter X with an associated response pattern to illustrate the nature of the ST and RT. All other procedures were the same as those used in Exp. IV except that the first test cycle was not presented until S had practiced for five consecutive practice trials.

Results

Total errors to criterion for test trials were recorded. (See Appendix D, Part 1 where means are summarized in Fig. 3.) As in all previous experiments the longer POST RT interval was associated with fewer errors, $F(1, 83) = 13.21$, $p < .001$. None of the other main effects or interactions were significant. The difference in blocks associated with whether or not English was the first language was significant, $F(1, 83) = 12.36$, $p < .001$.

The interaction effects noted in Exp. III and IV did not appear in Exp. V. The large variance in this experiment associated with Ss whose first language was not English was not controlled in the first two experiments. The data in the earlier two experiments are consistent with the interpretation that the obtained interactions were a function of the heterogeneous nature of the subject population with respect to English language facility.

The consistent finding of a significantly facilitating effect of lengthening the POST RT interval and no effect associated with the lengthening of the PRE RT interval is consistent with other research findings in the context of verbal responses (Bourne, 1966) and motor responses (Bilodeau, 1967).

The absence of effect associated with overt practice response, although consistent in general with findings in verbal learning (Underwood, 1963) differs from the finding of Cook & Spitzer who used a very similar procedure (1960). In the latter study S was provided an E controlled practice interval of 3 sec. while in Exps. III, IV and V the overt practice groups had an S controlled practice interval in addition to the PRE RT interval of either 0 or 4 sec. The S controlled practice procedure extended the interval between ST and RT by an average of 3 sec. A plausable account of the differential effects associated with overt practice in the Cook & Spitzer study and Exps. III, IV and V is that the critical events in forming associations precede the practice response and are independent of it. These events are implicit and may be mediational (Cook & Spitzer, 1960) in nature. If an unfamiliar overt response is required and its demand characteristics are such that most of the interval must be used in executing the response these events may be interfered with or abreviated. This source of interference may have a reduced effect when an extended POST RT interval is available since these implicit responses might readily follow the presentation of RT if ST is still available in memory. This argument leads to the prediction that the combination of an abreviated POST RT interval, a limited PRE RT interval and a required overt practice response during the PRE RT interval would be interfering when compared with the non-overt practice condition. This describes the condition under which Cook & Spitzer recorded the major source of interference associated with overt practice.

A second effect of overt practice in the earlier Cook & Spitzer experiment was that of producing an enduring response trace, since in that study responses were recorded by drawing. The resulting figure was present during the remainder of the trial. The effects of maintaining ST and RT during extended delay intervals has been shown to be facilitating (Bourne, Guy, Dodd, Justeson, 1965) but the effects of maintaining a response trace which in early practice is frequently incorrect is not clear. It was determined that for the overt practice conditions that the effects of maintaining the response trace would be studied since Exps, III, IV and V were not characterized by the avilability of such traces.

Experiment VI

It was the purpose of Exp. VI to investigate the effects of S paced and E paced anticipation practice intervals under overt and non-overt practice conditions. In addition the effect of maintaining or not maintaining the response produced trace was investigated.

Method

The apparatus was the same as that used in the previous experiment with the addition of a 28 v. light centered 1½ in. above each of the seven response keys. These lights were wired so that Ss assigned to the trace condition could turn on the light above a response key by pressing a response key and the light would remain lit until all three response keys were pressed and until the onset of the next stimulus term. A footpedal was also installed and positioned on the floor under the response console so that S could conveniently press it with the preferred foot. Lights in the response keys were colored so that the keys appeared a bright red when lighted during the presentation of of the response term (RT). Instructions and precedures were the same as those used in Exp. III with the first test trial following the first practice cycle. Taped instructions were used as in Exp. V. Ss in the non-overt practice mode were instructed to keep their hands clasped during the practice cycles, since some Ss on earlier experiments simulated the overt response by tracing the response pattern during practice trials. Instructions to the S control non-overt practice group required that S "think of the response term that followed the letter and then press the foot pedal so that the correct pattern could be presented". The three E paced groups were provided a fixed 3 sec. anticipation interval. All groups were given a fixed 1 sec. POST ST interval. For the three S paced groups the PRE ST interval extended from the onset of the 1 sec. stimulus display until a complete three key response had been completed in the case of the two overt practice groups or in the case of the non-overt practice group until the footpedal was depressed.

An incomplete factorial design with six cells resulted from the orthogonal comparison of E paced and S paced practice, trace and no trace indication, and overt and non-overt practice. No attempt was made to simulate a trace condition for the non-overt practice group and these two cells were left unfilled. Eighty-four Ss from undergraduate education courses participated as part of course requirements. Thirteen Ss were assigned to each of the six cells and data from 6 Ss were discarded due to procedural errors.

Results & Discussion

Total errors were recorded and means for each of the six conditions were summarized in Fig. 5. The means for all the overt practice groups were higher than for the two non-overt groups. An analysis including all groups in the incomplete design with all interactions assigned to the error terms yields a significant F ratio associated with practice mode, $F(1, 69) = 4.02$, $p < .05$. None of the other effects were significant.

When only the four overt practice groups were considered a factorial analysis yielded no significant effects except for an interaction between the presence of a trace whether the anticipation interval was *E* or *S* controlled, $F(1, 48) = 4.68$, $p < .05$. The interaction was an apparent function of the *increase* in error rate associated with *E* controlled pacing combined with the trace and the *S* controlled pacing combined with the no-trace condition.

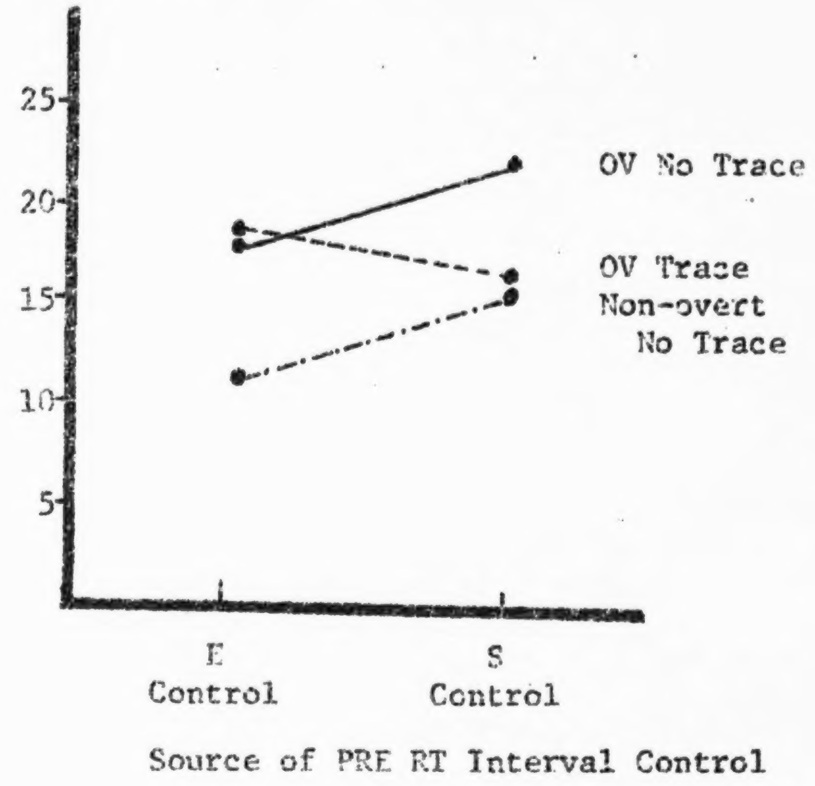


Fig. 5. Mean errors for response mode and response trace conditions as a function of *E* or *S* control at practice interval.

The results of Exp. VI were consistent with the Cook & Spitzer (1960) findings of interference associated with the production of overt anticipation practice responses. The fact that this interfering effect was not a significant source of variance in Exps. III, IV or V may have been a function of the relatively low power associated with tests of the practice mode effects under 0 sec. PRE RT and 1 sec. POST RT combination which was used in Exp. VI and the Cook & Spitzer study. If the interfering effect of the overt practice response employed in these experiments is dissipated within one or two seconds then either a PRE RT interval or a POST RT interval of this approximate length may be sufficient to ensure that the memory trace of ST and the available RT may be associated without that source of interference. If the association is facilitated by contiguity of ST and RT as is suggested by Estes (1964) and Stolurow & Lippert (1964) and the critical events are not the nominal stimuli but implicit representations of the ST and RT events then several consequences of practice mode may be suggested. One is that if the required practice response is an incorrect response or any other irrelevant response it may be expected to interfere only slightly with short-term retention of such a high frequency stimulus as an alphabet character (Peterson & Peterson, 1959). Further, extension of the anticipation interval by S̲ or extension of the POST response PRE RT interval by E̲ within the range examined and the occurrence or not of an overt practice response would be expected to have very little effect upon the availability of the ST. Interference may be expected as a function of extreme shortening of the PRE RT interval (Hunt, 1962) or completely filling the anticipation interval with a practice response if an implicit discrimination response is required which necessitates a brief but finite interval for its completion. Mere contiguity of S_T and correct practice response under conditions that required minimal discrimination of ST from the stimulus set have been reported to have contributed little or nothing to aquisition of a paired associate list (Greeno, 1964; Rothkopf & Coke, 1963; Faust & Anderson, 1967). The facilitating effect of contiguity of ST and practice response during extended over-training noted by Stolurow and Lippert (1964) may have been a function of the relatively greater demands for discrimination of ST from the stimulus set than was required in the prompted condition.

Other possible sources of interference associated with the overt practice response might be indicated. Although the separation of the ST display and the response console was only approximately 15 degrees of visual arc some time was required in changing fixation of the eyes from one display to the other. There was the occasional persistance in emitting practice responses beyond the anticipation interval into the RT display interval, and even into the POST RT interval. There may have been on occasion a failure to observe the following ST due to undue delay in practice response. Another possible source of interference with information displays associated with the overt practice mode was that it was possible to obscure part of the RT display with the hands if they were left in certain response positions during the RT display. Due to the physical arrangement of the response console this seemed to be possible only in rare circumstances but it was possible.

The interaction between the presence of the practice response trace and E̲ or S̲ control of the practice interval was consistant with an interpretation that S̲ required some time to discriminate a given practice response from RT and other practice responses. If the response trace was present but anticipation interval was filled the added display could not be discriminated with sufficient rapidity but if the anticipation interval were S controlled it would be possible to make the discrimination between the practice response trace and the RT display. In the absence of the trace the additional anticipation interval available in the S controlled mode may have resulted in some forgetting of initial elements of the three key response.

Experiment VII

If overt production of the correct practice response is a redundant, time-consuming activity in the acquisition of associations and interferes with implicit activity, and if association occurs during POST RT when both ST and RT are available the POST RT interval might be expected to be more interfering than during PRE RT. A comparison of overt and non-overt practice during the POST RT interval by Cook & Spitzer (1960) yielded little evidence of interference associated with overt practice. It seems that if the assumption of an interfering effect of overt practice is made then it may be argued that failure to show considerable interference may be due to the fact that the overt practice response during POST RT is highly prompted, is typically executed rapidly and without error so that an appreciable unfilled POST RT interval remains, given a fixed POST RT interval that is equal in length to the PRE RT interval.

It was the purpose of Exp. VII to investigate the effects of varying the requirements for overt practice during PRE RT and POST RT intervals that were sufficiently brief so that an overt practice response would approximately fill the interval.

Method

Procedures were the same as those used in the overt, no-trace, E controlled condition of Experiment VI with the exception that S was signaled to respond overtly by presenting him with a green light disk backlighting the stimulus display. He was told to make no overt practice response when a red backlight appeared (Appendix E). The lights appeared such that one group was instructed to make no overt practice responses (CC), one group to practice overtly only during PRE RT (OC), another group to practice overtly only during POST RT (CO) and the fourth group was instructed to practice overtly during both PRE RT and POST RT intervals (OO). The interval lengths were fixed at intervals that had been found to be sufficiently extended to include approximately 95 per cent of the practice responses. The intervals were 3 sec. for the PRE RT and 1.5 sec. for the POST RT intervals. A further modification was that of including two successive test trials on each cycle following the two practice trials to avoid the premature reaching of criterion due to the occurrence of a practice pair as close as one pair removed from its occurrence on a prior test trial. The apparatus was further improved so that responses were recorded on punched paper tape. To each of the four cells was randomly assigned 25 Ss for a total of 100. Ss participated to satisfy requirements in graduate education courses.

Results & Discussion

The data are summarized in Fig. 6. These data were subjected to an analysis of variance with the result that overt practice during the PRE RT interval was significantly interfering, F (1, 96) = 8.56; $p < .01$, as was practice during POST RT, F (1, 96) = 5.62; $p < .05$. There was no significant interaction between the two factors.

These findings are consistent with the findings of interference associated with both the PRE RT and POST RT intervals. Since the practice responses during POST RT were almost without error but nevertheless interfering it seems that the argument that overt practice is interfering primarily because of the high incidence of incorrect practice responses (Holland, 1965) is not adequate to account for these results. It seems rather that the practice response during POST RT may be correctly emitted without depending upon appropriate discriminating responses (Greeno, 1964) or precursory responses to the stimulus term and thus occupies time in activity that is not related to the establishment of the required associations (Holland, 1963).

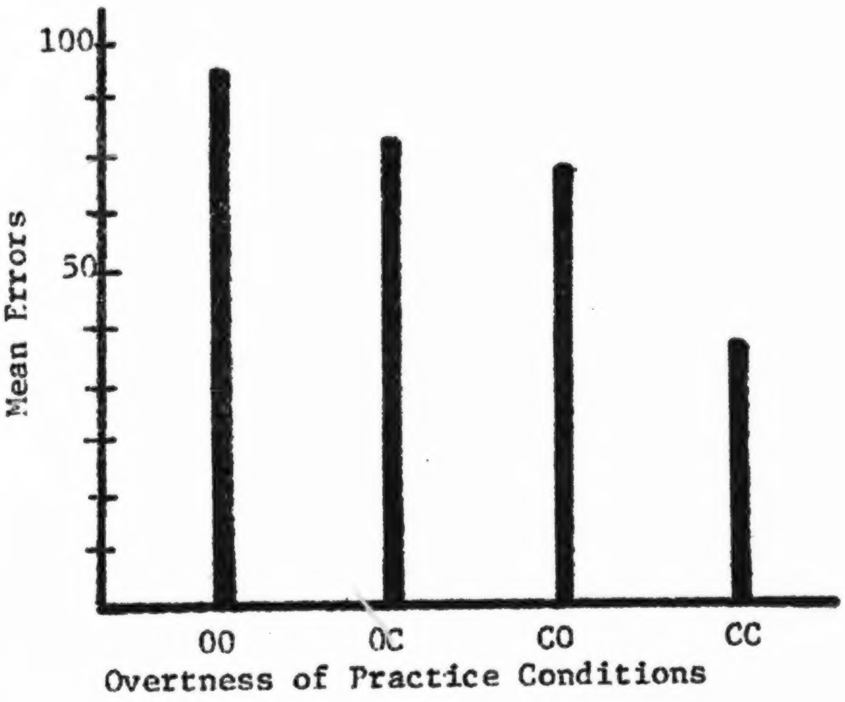


Fig. 6. Mean errors for combinations of overt (O) and non-overt (C) practice modes during PRE RT and POST RT intervals.

Controls were such that the possibility exists that task interference may have accounted for some of the interference in that the POST RT response may have been associated with delayed and inadequate orienting responses required for reception of the ST. Since the POST RT response occasionally exceeded the POST RT interval, S was still responding at the onset of the following ST. A similar problem existed during the PRE RT practice interval. However, in that case the RT display was contained in the response console and orienting responses appropriate for practice responses seem to have been generally adequate for attending to the RT display.

The absence of an interaction effect associated with increased errors with overt practice condition during both PRE RT and POST RT could be a function of the difficulty in obtaining control over the practice behavior of Ss (Lumsdaine, 1964). Incomplete practice response protocols were common, especially in the dual overt practice condition. Omitted overt responses were most frequent during early trials and it is during those trials that the interfering effect of overt practice seems most likely to occur. In spite of the fact that the instructions indicated required practice of a comparable task and the time intervals, although short, were found in pre-tests to allow adequate response time, Ss failed to respond overtly and reliably on each trial. If overt practice did interfere with essential implicit responses it may be that overt practice was omitted on trials during which these implicit responses extended throughout the practice interval.

Errors may be described as errors in response integration in which the three key pattern produced was not one of the correct possible patterns and errors in association in which the response was one of the possible correct patterns but associated with the wrong stimulus term. If production of the overt response has an effect upon response integration it would seem that responses during PRE RT which frequently consisted of errors in response integration might be associated with a relative increase in errors in response integration on test trials when compared with performance of Ss who emitted nearly errorless overt practice responses during POST RT. Conversely, association errors for the POST RT overt practice group might be increased by reason of the backward association of the contiguous and at times overlapping correct response to a given ST and the presentation of the following ST. The corresponding contiguity of response and inappropriate ST for the PRE RT practice group was comparatively very low. Inspection of the completed response protocols failed to reveal any significant differences between these two practice conditions with respect to either association or response integration errors.

Experiment VIII

Since control of response mode was found to be relatively inefficient in Exp. VII and the probability of task interference in terms of incompatable orienting responses required by the practice response and sensory reception of the stimulus events, particularly the ST were large, Exp. VIII was designed with attempts to improve control of these factors.

Method

The methods and procedures were the same as those used in Exp. VII with the following modifications introduced to attempt to better control practice and orienting behavior.

The time intervals during practice were altered such that the ST was displayed 1.2 sec. (See Appendix F, Part 1, for time line.). During the PRE RT condition requiring overt practice the keys were lighted green from the onset of ST until practice response had been completed or until 3 sec. had transpired. If by the end of 3 sec. at least one key press of the practice response had not occurred the key lights went off and a bell tone sounded together with the onset of a backlighted sign just above the ST display reading PRESS. S was then provided up to 2.4 sec. additional time to complete the practice response. If the practice response were not completed by the end of the extended practice interval the RT was displayed by lighting the indicator lights above the corresponding three keys for .6 sec. Thus, in the overt PRE RT practice conditions the RT was displayed either immediately following the completion of the practice response or 5.4 sec. following the onset of ST, which ever occurred first. The non-overt practice conditions differed in that the keys were lighted red and instructions were given indicating that while they were red they were to sit quietly and think of the correct three keys. If they pressed a key or moved their hands over the key board the bell tone sounded and the backlighted sign above the ST display read THINK. S's hand movements were observed through a system of mirrors by E and any movement of the hands over the response panel during non-overt practice intervals was the occasion for E's setting of a switch which sounded the bell tone and turned on the THINK light. The PRE RT practice interval for non-overt conditions was fixed at 3.6 sec. from the onset of ST (See Appendix F, Part 3, for instructions.).

The response contigencies with respect to duration of the practice interval and the occurrence of the warning bell tone and PRESS or THINK display were the same in the POST RT interval except that the duration of the RT was .6 sec., the red or green key lights were on for 1.8 sec. unless the practice response was completed earlier, the non-overt practice interval terminated 2.4 sec. after the onset of RT and if the overt response had not yet occurred the warning bell and PRESS signal occurred at 2.4 sec. also. An additional maximum of 1.2 sec. was provided overt practicing Ss that had not completed the practice response by 2.4 sec. after the RT onset.

The test trials were fixed for all conditions at 6 sec. duration including an initial display of ST for 1.2 sec. and a continuous display of the green response key lights until the last .6 sec. of the test trial (Appendix F, Part 2).

The procedures were presented during instructions by displaying three letter-key pairs that were not used in the regular criterion task. These pairs were displayed twice at a slow pace determined by the length of instructions and the latency of Ss practice response. They were displayed once at regular practice rate and a test trial on the three pairs was presented. All Ss successfully completed the instructional task.

In order to ensure that the overt practice during POST RT, or other factors associated with the physical characteristics of the display did not interfere with appropriate responses to the ST an additional control condition of either requiring or not requiring overt naming of ST on each practice trial was introduced.

Subjects -- Ss were from graduate education classes and participated as part of course requirements. In pilot studies and in Exp. VII it had been noted that Ss over thirty frequently had elevated error rates. It was decided to assign all Ss in this category to independent blocks. Two replications or 16 Ss from the total of 128 Ss were assigned to the older S blocks. In addition, the first six replications were treated as an independent block since an electrical short in the control equipment changed the criterion by systematically failing to record errors associated with two of the pairs.

Results

Errors were recorded for all test trials (See Appendix F, Part 3). The mean number of errors for the three blocks were 64.96 for the lower criterion block, 101.23 for the higher criterion block and 156.00 errors for the older S block. These groups differed significantly, F (2, 118) = 19.92, $p < .01$.

Since no interaction between these block effects and the independent variables was evident the data were pooled in the final analysis after partitioning out the significant blocks effect.

As in Exp. VII the PRE RT practice mode conditions differed significantly F (1, 118) = 15.18, p < .01. Again the overt practice mode was associated with increased errors. It was also the case that overt practice during the POST RT interval was associated with increased errors, F (1, 118) = 4.58, p < .05.

The naming or not naming of the ST was not associated with significant differences. None of the interactions were significant.

Exp. VIII gives no support to interpretations of interference in terms of failure to make appropriate orienting responses to ST. Furthermore, the fact that overt practice responses occasionally overlapped the following stimulus event in Exp. VII provided a basis for suggesting that the practice responses competed with appropriate orienting responses to both ST and RT. The modified procedures in Exp. VIII almost eliminated this overlap by providing response-contingent extensions of the practice intervals. The interfering effect of overt practice was maintained in Exp. VIII in spite of these modifications.

The interpretation of a relatively neutral but time-consuming function associated with the overt production of the practice response is consistent with this experiment. If association learning procedes rather independently of the overt response then results such as those obtained would be expected. Differences might be accounted for, however, if it is recognized that error rates are high during anticipation intervals and under these circumstances interference associated with overt practice might be predicted according to contiguity or reinforcement theory while the effect of non-overt practice depends upon the nature of the response emitted and in the case of suspended responses when errors are likely interference would be greatly reduced. Accounting for the interfering effect of errorless overt practice during POST RT in these terms is more difficult but it might be argued that appropriate "precursory" behavior (Holland, 1965) is made less likely by the procedure requiring rapid duplication of a brief display.

It is also difficult to account for the observation that in Exps. VII and VIII interference associated with overt practice mode is not restricted to the POST RT interval as might have been expected from Exps. III, IV and V. In those experiments only the POST RT interval length was associated with significant changes in error rate while variations in PRE RT was not. If reduced POST RT forces *S* to borrow time in successive PRE RT intervals and if overt practice effectively reduces POST RT then we should have observed an interaction between POST and PRE RT practice mode conditions. This interaction was not obtained in either experiment. If a borrowing phenomenon occurred it would have seemed that in Exp. VI that the unrestricted *S* controlled PRE RT practice condition should have been more effective than the restricted *E* controlled condition. Again, no significant difference was obtained. Bourne *et al* (1965) have noted, however, that *S* control may be rather inefficient since *S* may not select the most effective intervals.

Experiment IX

In order to make an additional test of the possibility that PRE RT interference may be a function of shortened POST RT intervals Exp. IX was planned with *E* controlled variations in interval lengths.

Method

The response panel, display and control apparatus were the same as in earlier experiments. Eight stimulus letters were used including E, F, R, S, X, Z, L, and Y. The paired response patterns were similar to those used on previous experiments. The eight pairs were assigned to PRE RT interval conditions such that four pairs were consistently associated with a 4 sec. PRE RT interval (L_n) while the other four pairs were consistently associated with an 0 sec. PRE RT interval (S_n). The PRE RT interval followed the completion of the practice response interval which was *S* controlled, and was terminated by the presentation of the RT stimulus. The POST RT interval was 1 sec. Two of the four stimulus pairs assigned to the L_n condition and two of the four stimulus pairs assigned to the S_n condition always preceded stimulus pairs which were assigned to the L_n condition so that on trial N + 1 the PRE RT was always relatively longer (L_{n+1}). Similarly the other two pairs of the L_n and S_n always preceded on practice trials stimulus pairs which were assigned to the S_n condition so that on trial N + 1 the PRE RT was always relatively shorter (S_{n+1}). Two training trials were followed by a test trial that differed only in that the RT was not presented. Training continued until two consecutive errorless test trials were attained (Serial order of practice and test items is given in Appendix G, Part 11).

Four counterbalancing conditions were used such that a given pair of letter-key pairs was assigned successively to a different PRE RT_n, PRE RT_{n+1} condition on each of the counterbalancing conditions.

Twenty Ss from undergraduate educational psychology classes were assigned on a random basis to each of the four counterbalancing conditions such that five were assigned to each condition.

Results & Discussion

Errors were tabulated for each S by PRE RT interval on trial N and trial N + 1 for both training and test trials. Although the means for the POST RT interval conditions were distributed similarly in training and the test trials it was only on test trials that any differences were reached with significance (See Appendix G, Part 2 for error data.). The longer interval on trial N was associated with significantly fewer errors, $F(1, 16) = 8.00$, $p < .05$. No other differences were significant.

This difference on trial N was not obtained at a significant level in Exps. III, IV, and V nor by Bourne and Bunderson (1963) in a concept identification experiment using similar intervals. However, the obtained differences were in the direction of facilitation associated with a lengthened PRE RT. Hunt (1962) has reported a facilitating effect of a lengthed PRE RT interval. He suggests that the interval may be facilitating in that it provides time for information processing events that may occur during PRE RT. The mixed list design of this experiment provides a basis for extending arguments of a facilitating effect of lengthened PRE RT from constant interval lists to the mixed interval lists.

The hypothesised interaction of the trial N interval with the interval on trial N + 1 was not supported. It should be observed that the anticipation practice interval was S controlled and no latency data was gathered. It is possible that S compensated before rather than after the practice response for shortened interstimulus intervals on the previous trial.

RESPONSE CONTINGENT INVERVAL LENGTH

Experiments X through IXX

The next nine experiments were designed to make a variety of related tests of the assumption that the PRE RT and POST RT intervals might be expected to have differing effects following a correct or an incorrect practice response. The strategy selection model suggests that resampling only occurs following errors (Restle, 1962). If the Pre RT interval itself provides no information regarding the correct practice response then it would seem that extending this interval following either a correct or incorrect response should make no difference whereas following RT that disconfirms an incorrect practice response facilitating resampling activity might occur if POST RT is extended while no resampling activity is expected if RT confirms a correct practice response.

Experiment X

In Exp. IX it was found that extending the PRE RT interval facilitated learning. The design did not permit the separation of the effects of the extended interval following a practice error and following a correct response. If the effect of extending the PRE RT interval following the response is to allow repeated implicit practice of the response then the extended interval would seem to benefit most following a correct practice response. If, however, the extended interval provided sufficient time for implicit correction responses which may be available after the response and before RT then the extended interval might be most beneficial following errors. Similarly, an extended PRE RT interval would be expected to facilitate following errors more than correct responses if the extended interval provided time for the extinction of the incorrect response which would then provide less interference with the RT. The purpose of Exp. X was to compare the effects of extending the PRE RT interval following correct practice responses with the effect of extending the PRE RT interval following incorrect practice responses.

Method

Materials and procedure were the same as those used in Exp. IX except that four of the letter-key pairs were programed such that following a practice error the PRE RT interval was 0 sec. and following a correct practice response the PRE RT interval was 4 sec. (L_{error}). The other four letter-key pairs were programed such that following a practice error the PRE RT intervals was 4 sec. and following a correct response it was 0 sec. (S_{error}).

Twenty-eight Ss from undergraduate educational psychology classes served as part of course requirements. Due to apparatus difficulties 16 were discarded. Discarded Ss were distributed in an unbiased manner across conditions. The remaining 12 Ss were assigned in a randomized fashion to the four counterbalancing conditions, as described in Exp. IX, such that there were three Ss per condition.

Results

Except for a difference between the counterbalancing conditions in test trials, there were no differences that were statistically significant. The obtained numerical difference on both test and training, across trials showed a slight but consistent advantage for the extended interval following errors (L_{error}) (See Appendix H for summary of results.).

Experiment XI

The strategy selection model (Restle, 1962) would seem to be more consistent with a prediction of a differential effect in the POST RT interval than during the PRE RT interval. It was the purpose of Exp. XI to determine the effects of varying the POST RT interval as a function of the correctness of the anticipation practice response.

Method

The procedures were identical with those of Exp. X except that the interval varied was the POST RT interval rather than the PRE RT interval. Twelve Ss were assigned equally to the four counterbalancing conditions and 7 Ss were discarded due to apparatus difficulties.

Results

The results were generally consistent with those of Exp. XI. That is, there were no statistically significant differences associated with the independent variables although, again, there was a numerical difference favoring the condition of extended POST RT following incorrect practice responses (L_{error}) (See Appendix I for summary of results.).

Experiment XII

Although a significant POST RT effect had been obtained in each of the earlier studies designed to test it independently it seemed possible that this effect may have been reduced in Exp. XI because of the mixed list paradigm employed. If Ss withhold responses during the interval of variable length then differences between POST RT conditions may have been reduced in Exp. XI. In order to test this possibility the POST RT interval was made contingent upon the stimulus rather than upon the correctness of the practice response.

The procedure was gain identical with that of the previous experiment except that the length of POST RT was always extended for four of the pairs and always at 0 sec. for the other four pairs. The same counterbalancing procedure was employed. Ss from the same population were employed with 12 assigned equally to the four counterbalancing conditions. Five additional Ss were discarded due to apparatus failures.

Results

The differences between the POST RT interval conditions were in the direction of fewer errors associated with the extended interval on both training and test trials. The difference reached a significant level on the test trials, $F(1, 8) = 7.79$, $p < .05$. There was also a significant interaction with the counterbalancing condition, $p < .05$ (See Appendix J for summary of data). This finding does not support the assumption that the mixed list paradign results in suspension of implicit responses during the extended interval. It may be noted, however, that the magnitude of the difference between the interval conditions is proportionately much less than that obtained in Exps. III, IV and V. The many procedural differences do not permit a simple comparison, however.

Experiment XIII

The failure to find any significant differences associated with PRE or POST RT length contingent upon correctness of practice response could be attributed to a number of experimental design and control factors. The apparatus for controlling the contingency studies was complex and unreliable resulting in an unusually high ratio of inadequate response records. Although evidence of systematic bias was not noted it seemed possible that improving the reliability of the apparatus would make possible a more adequate test of the independent variables.

Furthermore the power of the previous contingency experiments was low due to the small number of Ss used and the relatively high error variance. This fact combined with the consistent finding of a small, insignificant numerical reduction in error associated with extended intervals following errors suggested the advisability of a more powerful test. Exp. XIII was essentially a replicatiion of Exp. XI with added Ss and improved apparatus reliability.

The procedure was identical with that of Exp. XI except that Ss completed 14 practice test cycles rather than continuing to a criterion of two errorless trials. Twenty Ss were assigned randomly to the four counterbalancing conditions such that five were assigned to each condition. No Ss were discarded.

Results

There were no differences between conditions on either training or test. The data were examined for any trials by conditions interaction. This interaction was not significant. There was no evidence of a numerical difference between the L_e and S_e conditions on either practice or test trials (See Appendix K.).

Experiment XIV

This experiment was conducted to replicate Exp. X including the same apparatus and all the additional changes employed in Exp. XIII, that is 20 Ss and improved apparatus reliability. The contingent interval was the PRE RT interval.

Results

The results were identical with those of Exp. XIII. That is, there were no significant differences obtained as a function of the contingent PRE RT time interval conditions. The previous null results associated with both PRE and POST RT conditions raised the possible hypothesis that a consistent extended time interval condition associated with a particular stimulus response pair may be facilitating while a response contingent extension of the interval is not. Another possibility is that extension of the PRE and POST RT intervals was facilitating following both a correct and an incorrect practice response. If this were the case, the differential effects of the L_e and S_e conditions would be reduced.

Experiment XV

In the next two experiments the effects of interval lengths contingent upon correctness of practice response were compared with interval lengths that were reliably associated with paired associate pairs independent of practice response performance. In Exp. XV the interval varied was the PRE RT interval and in Exp. XVI it was the POST RT interval.

In both Exps. IX and XII a significant effect associated with extended intervals was found while in Exps. X, XI, XIII, and XIV no significant differences were found. The first two experiments were characterized by including a constant extended interval condition associated with a given stimulus response pair while in the last four experiments the extended interval was contingent upon the correctness of the practice response. This relationship between constant and contingent extension of practice interval held for both extension of the PRE and POST RT interval.

The present experiment was designed in order to make a direct comparison of the effects of extending the PRE and POST RT intervals under constant and contingent conditions.

Procedure -- The eight stimulus response pairs were grouped into sets of two pairs resulting in four sets. The PRE RT interval condition associated with the pairs was respectively constant long (L) or 4 sec. following each practice response, constant short (S) or 0 sec. following each practice response, long contingent upon a practice error (LE) or 4 sec. if an error and 0 sec. if a correct response, and short contingent upon a correct practice response (SE) or 4 sec. if correct and 0 sec. if an error occurred. Counterbalancing, procedures, apparatus and subject population were the same as in the previous experiment. Twelve Ss participated.

Results

No differences, except the uniformly obtained significant trials effect, were obtained on practice trials. On test trials, however, a significant effect associated with extending the PRE RT interval was obtained, $F(3, 24) = 4.71$, $p < .01$. A further comparison of the means using the Neuman-Keuls test (Weiner, 1962) indicated that the L condition was associated with fewer errors than any of the other three conditions, $p < .01$, while the other three means did not differ significantly (Sée Appendix L.).

This finding is consistent with the interpretation that a consistent extension of the PRE RT interval is facilitating while a correctness of response contingency for interval extension is associated with a decreased interval effect.

Experiment XVI

Procedure -- This experiment was identical with Exp. XV in all respects except that the extended intervals occurred during POST RT and a total of 16 Ss participated.

Results

The results were identical with those of Exp. XV. The extended interval effect was significant, $F(3, 36) = 3.52$, $p < .05$, on performance during test trials. No other effects except trial effects were significant. The Neuman-Keuls range test was again employed to test the differences between the means of the four extended interval conditions. Again, the mean number of errors for the L condition was significantly lower than that of any other group. In addition the LE condition differed significantly from the S, $p < .05$ and from the SE, $p < .01$ conditions.

The finding of a significant difference associated with the LE condition of lengthened POST RT is consistent with the interpretation that following errors an implicit correction response may occur following the presentation of RT. The fact that the L condition also differed for the LE condition may indicate that either the extended interval facilitates following both errors and correct practice responses or that the mixed interval condition does have the effect of suppressing the effects of the reliably available interval. The fact that LE differed from SE could be a function of the relative occurrence of errors and correct responses over trials. Since errors occur at the beginning of training there is no basis for discriminating between an item in the L condition and an item in the LE condition until a correct response occurs. This fact may result in the facilitating LE effect occuring primarily during the early practice trials. However, no trials by interval effect was observed in this experiment (See Appendix M.).

Discussion

Experiments IX through XVI

Experiments IX through XVI were very similar with respect to procedure, materials, design and subject population. All of the studies were characterized by a mixed list design comparison of extended PRE or POST RT intervals contingent upon either correctness of practice response or the occurrence of a given stimulus response pair.

In making a general comparison of these studies with earlier results in this series it is apparent that the magnitude of the differences between interval conditions is greatly reduced and evidence of any differences between PRE and POST RT interval condition seems to have disappeared. Many factors could be responsible for the differences in the findings but it seems that the mixed list design is the major factor contributing to the difference in results between the two sets of experiments. Post experimental inquiry indicates that a majority of the _Ss_ were not aware of the fact that the length of practice intervals differed. The few that seemed to have noticed it frequently attributed the differences to unreliability of the apparatus. This failure to notice the differing interval conditions was particularly noted in the correctness-of-response contingency studies. If the effect of the extended interval is to increase the probability of implicit practice responses and if these responses are contingent upon _S_'s discrimination of those items that include the extended interval, then the mixed list design in general and the contingency conditions in particular would seem to reduce the probability of making such discriminations.

Although no direct comparisions between PRE and POST RT conditions were made in this series, the successive experiments were sufficiently similar to provide the basis for the general observation that no evidence of interaction between interval condition and serial order of extended interval and response term was observed. This absence of interaction seems inconsistent with the relatively much stronger POST RT effects found on earlier studies in this series and absence of significant PRE RT effects. It seems that the mixed list design has the effect of reducing the magnitude of effects associated with extending POST RT even more than those associated with PRE RT extension. If this is the case, it may suggest that the facilitating effects associated with extending the two intervals are functions of different processes. For example, extending PRE RT may facilitate discrimination of emitted response and the RT while POST RT may provide for further rehearsal.

Experiment XVII

Although PRE or POST RT locations of the extended interval were not differentially associated with extended interval effects in Exps. IX through XVI there had been no direct comparisons. Since the location of the extended interval had been a source of significant difference in Exps. III through V it seemed that a direct test should be made. Furthermore, since the magnitude of the obtained differences were relatively very small in the IX through XVI series it was felt that the power of the experimental design would make possible a more reliable comparison of effects associated with the length of the interval and location of the interval.

Procedure -- Experimental procedures in Exp. XVII were the same as those used in the earlier two experiments except that serial order of the extended interval was independently manipulated resulting in the PRE RT and POST RT conditions. The interval conditions were orthogonal to the four counterbalancing conditions resulting in 8 cells. Nine Ss from the previously sampled population of undergraduate educational psychology classes were randomly assigned to each of the cells resulting in a total of 72 Ss. The within list variation in interval contingency were the same as in the earlier two experiments with two pairs reliably associated with a long interval (L), two a short interval (S), two long if a practice error occurred (LE) and two short if an error occurred (SE).

Results

Total errors for each extended interval condition were tabulated for the PRE RT and POST RT conditions across each of the counterbalancing conditions. The means associated with the four contingency conditions on test trials were respectively 6.33 with L, 7.08 with LE, 7.71 with SE and 8.32 with S, with a similar ordering of values on practice trials.

An analysis of variance of the error data including both practice (P) and test (T) trials across eight P-P-T cycles showed expected learning effects across trials, $F (7, 448) = 339.47$, $p < .001$. Performance also differed significantly on the two practice and test trials, $F (2, 128) = 156.98$, $p < .001$. This difference was in the direction of decreased errors from the first practice trial to the second and similarly from the second to the test trial. The difference, however, between the test trial and the following practice trial indicates a slight numerical increase in number of errors. This observation tends generally consistent with the earlier assumption made concerning the effect of interpolating no outcome trials in the practice sequence, that the interpolated no outcome test trial would not be expected to result in increased errors on successive practice trials. Greeno (1964) has shown that the effect of such interpolated trials depend upon a number of practice conditions but in general is similar in effect to those that were found in this experiment.

The practice contingency interval effects were again found to differ significantly, $F (3\ 192) = 9.15$, $p < .001$. The Neuman-Keuls (Weiner, 1962) interval test showed that each of the means differed from each of the other means in an increasing order of errors from L to LE to SE to S, $p < .01$. This finding was generally consistent for both the PRE RT and POST RT conditions and for both practice and test trials, although a complex interaction effect between counterbalancing, PRE-, POST-RT, P-P-T blocks, and contingency conditions was found, $F\ (18,\ 384) = 1.71$, $p < .05$. The magnitude of the effect was small and the number of variables so large that no interpretation of the interaction was possible. The extended interval effects were consistent with the earlier two experiments and may be summarized by observing that the extended interval was found to be facilitating, especially but not exclusively following an incorrect practice response.

Before more is said about this interval effect it must be noted that a significant interaction effect was obtained between the counterbalancing conditions and the extended interval conditions, $F\ (9,\ 192) = 5.91$, $p < .001$. This interaction seems to reflect in large part the fact that the sets of two pairs of items assigned to each of the interval conditions differed in difficulty. This difference in difficulty seems to have been a function of both the relative frequency in the language of the stimulus term; for example, Z, X set being more difficult than the R, L set and with the complexity of the associated response terms such that the RTs of the Z, X set including non-contiguous keys while both the R and L RTs including contiguous keys. When the extended interval conditions are plotted by the stimulus-response pairs rather than the counterbalancing conditions the magnitude of the interaction is noticeably reduced. The two alternative ways of plotting the data are illustrated in Fig. 7. There were no differences obtained between the PRE and POST RT conditions or the counterbalancing conditions and none of the remaining interactions were significant.

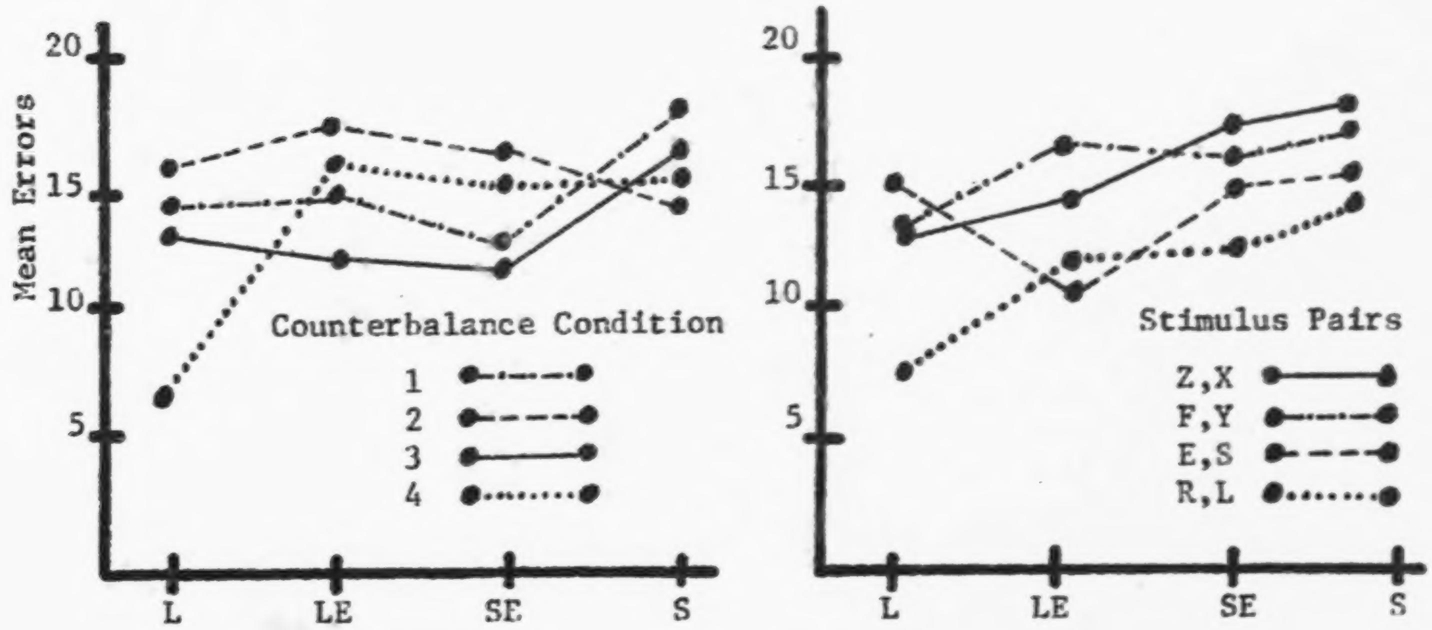


Fig. 7 Errors as a function of interval conditions plotted first by counterbalance and secondly by Stimulus Pairs.

The finding that extending the interval following a correct practice response was facilitating is most difficult to interpret in terms of the strategy sampling assumptions (Restle, 1962). According to these assumptions in the POST RT situation following a confirmation of a correct response no further sampling occurs. In the PRE RT situation S has selected the strategy and is awaiting the RT. When he selects the correct strategy nothing that follows except possibly forgetting is assumed to further facilitate or interfere with the resulting association. However, in the present experiment facilitation did occur as a function of extending either the PRE RT or the POST RT intervals following a correct practice response. If it is assumed that the extended interval provides for overtraining then the James and Greeno (1967) findings of absence of overtraining effects associated with early conditioned items in a list prior to the attainment of criterion seem inconsistent with these findings. Since training in this task was only carried to criterion and not overtraining then the question remains regarding why the extended interval seemed to provide for the conditioning of additional cues by permitting additional implicit rehearsal responses when it seemed that this did not happen in the James and Greeno study.

Experiment XVIII

In Exp. XVII practice responses were overt with an S controlled response interval. The effects demonstrated in Exp. XVII could be attributed to the possibility that during the extended intervals the interfering effects (Cook & Spitzer, 1960) of overt practice responses and extended anticipation intervals were extinguished. Although earlier experiments in this series were not sensitive to interference from these sources the procedure of separating the correct and incorrect practice responses may provide a more sensitive measure of these types of interference. Four of the critical events in anticipation mode of practice were manipulated independently in this experiment. The anticipation interval preceding and including the practice response, the overtness of the practice response, the PRE RT interval and the POST RT interval.

Procedure -- The procedures and apparatus were the same as that used in Exp. XVII except that two independent variables were added. The anticipation practice response was either overt as previously, or not overt for the Ss in a given condition of overtness of practice. A second variable was the control of the length of the anticipation practice interval. In the third controll condition the interval was extended from the onset of ST to the completion of the three key response or in the case of the non-overt groups until a foot pedal was depressed signaling that S had "thought of a response" as directed by the instructions. The E controlled practice intervals were determined empirically by noting that the mean time for executing the practice response was 2 sec. and the delay before initiating the first key response was 1 sec. Consequently the overt practice condition was allowed 3 sec. to make the overt practice response and the non-overt condition was allowed 1 sec. to "think of the correct response".

In order to investigate the effects of extending the practice intervals contingent upon the correctness of responses a new procedure was included which made practice intervals con--tingent upon the correctness of responses during test trials rather than practice trials. This was accomplished by employing transistorized logic equipment which stored the correctness of each response during a given test trial. On the two immediately following practice trials the extended PRE or POST RT interval for the LE and LC conditions was contingent upon the correctness of that particular practice response on the prior test trial. The storage was cleared at the beginning of the next test trial and was re-set depending upon performance on that test trial. This storage arrangement continued throughout all practice trials. In order to determine the comparative effects of intervals contingent upon performance on the previous test trial with intervals contingent upon performance in the immediately preceding anticipation practice response two additional groups were included that replicated the procedures of Exp. XVII in that intervals for PRE RT and POST RT condition were contingent upon the practice performance and not upon the stored results of the prior test trial performance.

The 128 Ss were students in introductory educational psychology classes that participated as part of course requirements. They were assigned to the 32 cells resulting from the orthogonal partitioning resulting from two levels of overtness of practice, two conditions of control of the length of the practice interval including E and S control conditions, two sequential arrangements of extended interval and RT including PRE RT and POST RT and the four counterbalancing conditions. The assignment of Ss to cells was random with the restriction that an equal number was assigned to each cell.

Results & Discussion

Errors were tallied separately for each stimulus pair and grouped by contingency interval condition for each S within each treatment contition. Means for each of the conditions are presented in Table 1.

Table 1. Mean Errors for Each Practice and Inter-Stimulus Interval Condition, Experiment XVIII.

OVERT

Interval Contingency		Automatic (3 sec.)		S-Paced	
		PRE-IF	POST-IF	PRE-IF	POST-IF
Incorrect	Correct				
L	L	7.75	5.45	6.00	9.25
L	S	8.50	7.38	6.64	10.14
S	L	8.38	8.43	7.38	10.07
S	S	9.43	8.50	8.31	10.31

NON-OVERT

Interval Contingency		Automatic (1 sec.)		S-Paced	
		PRE-IF	POST-IF	PRE-IF	POST-IF
Incorrect	Correct				
L	L	7.62	8.75	7.75	7.25
L	S	7.20	7.56	7.82	10.00
S	L	10.14	7.63	8.38	9.36
S	S	10.00	8.70	7.13	11.50

The first comparison of groups was made on the data from the overt practice conditions which differed with respect to whether responses were contingent upon the previous test trial performance or upon the current practice anticipation response. No main effects or two-way interactions associated with the storage contingency conditions were significant. There were, however, several significant effects associated with higher order interactions that involved the storage contingency factor. Although several of these interactions included both the storage condition and the extended interval condition the magnitude and direction of the effects of extending the PRE and POST RT intervals was the same as that found at the main effects and two-way interaction levels of the earlier experiment. These results showed a consistent decrease in errors associated with an increase in the PRE or POST RT interval with the errors decreasing reliably from L to LE to LC to S conditions.

The conditions were then compared which had included the test trial contingency procedure. No significant difference was obtained between the overtness of practice conditions, between the automatic and S-paced conditions, or between the PRE or POST RT position of the extended interval. The only significant main effect obtained was the contingency interval condition, $F(3, 288) = 5.61$, $p < .01$, with a subsequent Neuman-Keuls interval test indicating that the serial order of L 7.72; LE 8.18; LC 8.70; and S 9.25 being reliably different for each of the adjacent pairs. The only interaction between contingency intervals and other conditions obtained was the previously found interaction with counterbalancing which again seemed to be primarily a function of the fact that the stimulus response pairs assigned to each of the contingency conditions differed in difficulty and consequently were associated with corresponding elevations or depressions of the scores for a given interval condition in a given counterbalancing condition.

Experiment XIX

The last experiments in this series were conducted in an attempt to investigate the relationship between overtness of response and performance under rapid E paced anticipation interval conditions. In none of the previous experiments has emitting an overt practice response been shown to be relatively more efficient than providing an unfilled anticipation interval, even though the anticipation might be reduced in time when compared with the time available for executing the overt practice response. It has been earlier suggested that the overt practice response may contribute nothing directly to the acquisition task and that under some conditions may interfere with acquisition. There is, however, evidence from very different contexts

(Perry, 1939; Jaspen, 1950) that if the criterion task includes a rapid E paced performance level that prior overt practice may result in relatively more rapid and accurate performance than non-overt practice.

It was the purpose of this experiment to investigate the relative effects of overt and non-overt practice under initial practice conditions of a relatively longer duration of anticipation interval and under later conditions of reduced duration of anticipation interval.

Procedure --The stimulus materials and apparatus used in this experiment were the same as those used in Exp. V, except as noted below. The Ss were required to learn the six 3-key responses to the alphabetic stimuli. The criterion task was to maintain accuracy of response for two consecutive anticipation practice trials after practice trial number 40. A green jeweled light was mounted 1/2 in. above the stimulus display and was lighted immediately at the completion of a correct anticipation response and remained lighted until the onset of the next stimulus term. The trial length was 6 sec. during the first 40 trials and 4.5 sec. during the last 40 trials. On the first 40 trials the stimulus letter was displayed for 5 sec. and anticipation responses were evaluated for the first 3.5 sec. following the stimulus letter onset. After a 5 sec. delay the correct key pattern (RT) was then displayed for 1 sec. and that was followed by an unfilled 1 sec. interval. During the last 50 speed trials the anticipation and ST display interval was shortened by 1.5 sec. which allowed a 2 sec. anticipation interval. The ST was backlighted during the anticipation interval with a green disk when an overt response was required and with a red light when he was instructed to keep his hands clasped in his lap and not respond overtly.

On the first 20 practice trials all Ss were signaled to keep their hands clasped (N-OV). On trials 21 and 22 all Ss were signaled to respond overtly and half of the Ss were required to continue responding overtly up to trial 40 while the other half was N-OV. From trial 41 to 50 the two practice groups were each randomly divided into two groups with one OV and the other N-OV. From trial 50 through 90 all Ss practiced overtly or until any S attained the criterion of two consecutive errorless trials.

The 80 Ss from undergraduate educational psychology classes were assigned randomly to the four conditions such that there were 20 in each condition.

Results

The performance of each of the conditions over trials

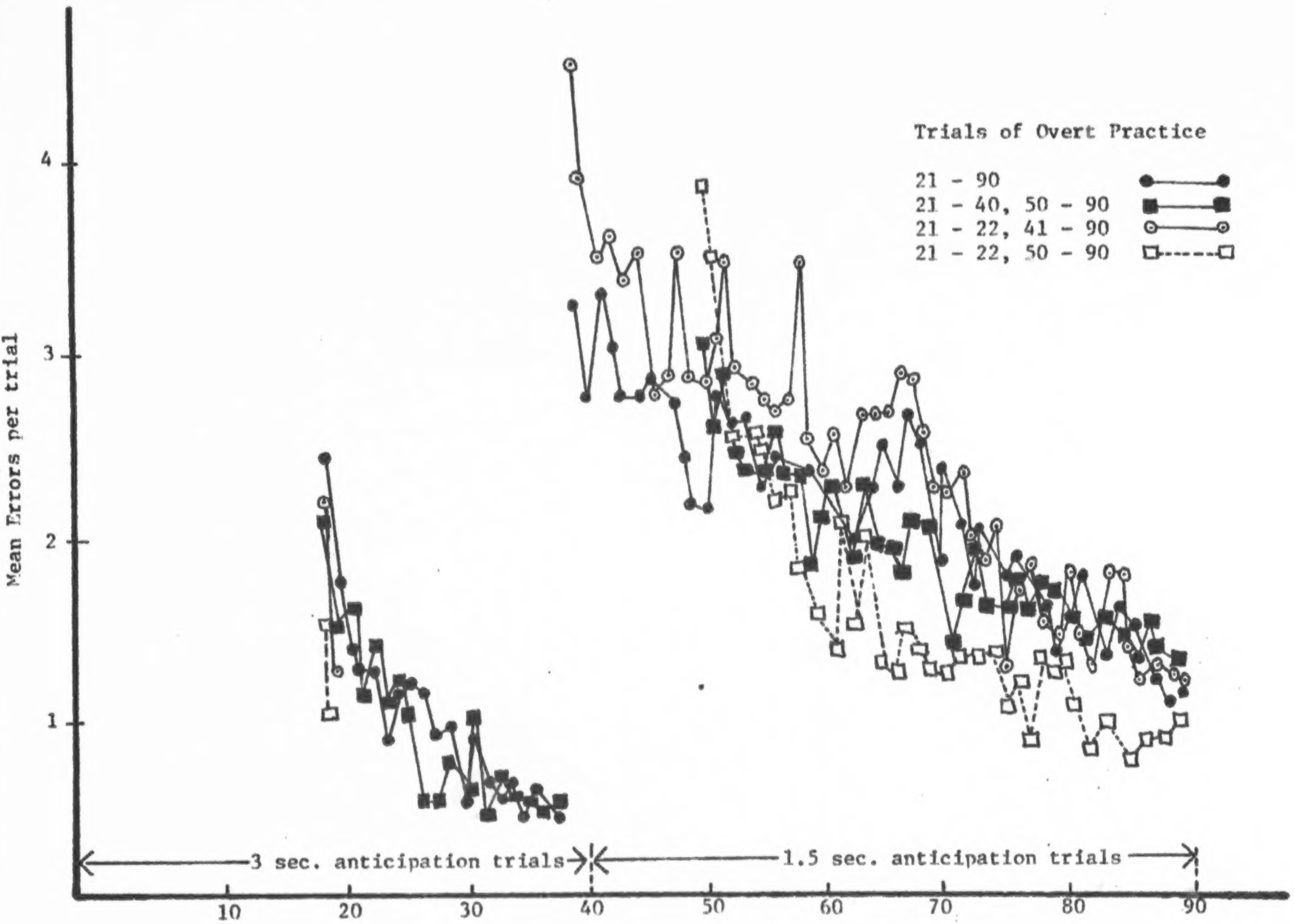


Fig. 8. Mean Errors for groups with varying amounts of prior overt and non-overt practice as a function

is summarized in Firgure 8. First, the groups were compared on trials 51 through 90. The mean number of errors over trials did not differ among the four groups. The errors decreased significantly over trials but there was no trials by condition interaction. It is interesting, however, to note that in initial overt trials following extended covert training trials there is a noticeable but temporary increment in errors at trial 21, 41, and 51. This increment is due primarily to the category of errors characterized by complete omission of any key press during the practice interval. Within a few trials the omission error is greatly reduced and the error rate is similar to performance by the OV/OV group. It seems likely that the non-overt practice condition is effective in providing for correct associations but is not effective in providing appropriate control of rate of response. The rapidity with which the rate is established suggests that it may be more a matter of appropriate information feedback regarding the appropriate rate of response than the conditioning of the overt response itself.

Experiment XX

The differences between practice groups in Exp. XIX were not significant. It seemed possible that the absence of difference favoring the overt practice conditions given a speed criterion look similar to those obtained in studies such as the Jaspen (1950) and Perry (1939) might have been attributed to methodological differences. In Exp. XIX all groups were given twenty trials of non-overt practice. This phase of practice is characterized by relatively frequent overt practice errors. It is possible that there may be some advantage to the overt practice conditions attributable to an unlearning mechanism that is facilitated by the overt production of the incorrect response and its subsequent disconfirmation (McGovern, 1964). Another possibility is that the two overt test trials on trials 21 and 22 may have provided the occasion for sufficient practice or information feedback to override any disadvantage attributable to non-overt practice. The effectiveness of interpolated test trials in facilitating learning is not uniformly found but is in some cases facilitating (Greeno, 1964; Lumsdaine, 1964). Another possibility is that the amount of differential practice may have been insufficient to achieve a reliable difference between practice conditions. This seems especially likely in the case of the post rate shift trials from trial 41 to 51.

Experiment XX was designed to further examine the effects of practice mode upon performance under reduced anticipation interval conditions. In particular the effects of overt practice on initial trials, interpolated overt practice trials following initial training trials and extended non-overt practice under reduced anticipation interval conditions.

Procedure -- The procedures were identical to those of Exp. XIX except that the location of trials of overt and non-overt practice differed. The OV $_{1-90}$ group practiced by overt anticipation from trial 1 through trial 90. The OV$_{21-90}$ group practiced non-overtly through trial 20 and overtly following trial 20. The OV $_{21-22,\ 71-90}$ group practiced by observation only from trial 1 through trial 70 except on trials 21 and 22 and 71 through 90. The OV $_{71-90}$ N-OV group practiced by observation alone except on trials 71 through 90.

The 80 Ss who participated as part of course requirements in undergraduate educational psychology classes, were assigned randomly such that there were 20 in each group. The total number of errors were recorded for each group and are presented across trials in Figure 9. The marked learning effect for the OV $_{1-90}$ group is apparent for the first forty trials during the extended 3.5 sec. anticipation condition. However, during the reduced 2.0 sec. anticipation interval this group showed no further improvement. The OV $_{21-90}$ group showed a precipitous decrease in error rate on trials 22 and 23 and performed significantly better than the OV $_{1-90}$ group, $F(1, 38) = 10.34$, $p < .01$. The advantage of non-overt over overt practice, given relatively brief anticipation intervals and short POST RT intervals found in this study was consistent with earlier findings in Experiments VIII and IX.

There was no significant difference between these two conditions, however, following the increase in response rate, inspection of the error curves does reveal, that on 41 or the 50 trials the group that had no overt practice for the first 20 trials performed better than the group that had. If there were any advantage which a more powerful test should reveal it might be attributed to the fact that the OV $_{1-90}$ group was still making significantly more errors by trial 40 than was the OV $_{21-90}$ group and perhaps further learning beyond trial 40 could not be expected to occur under the conditions of rapid practice for 50 trials. There is no evidence in the obtained data to indicate that the initial production of erroneous overt practice responses interfered with performance beyond trial 40.

The rapid decline of omitted errors on initial trials following non-overt practice was replicated in this experiment. Group OV $_{71-90}$ made more errors on the first two overt practice trials than the other groups that had been practicing overtly, $F(1, 59) = 29.26$, $p < .01$. This difference then disappeared for the remaining trials. When these errors were analysed for type of error it became clear that the only type of error to change markedly was the omission error which dropped out by the third trial. It seems that responses and associations are (See Appendix N for error analysis.)

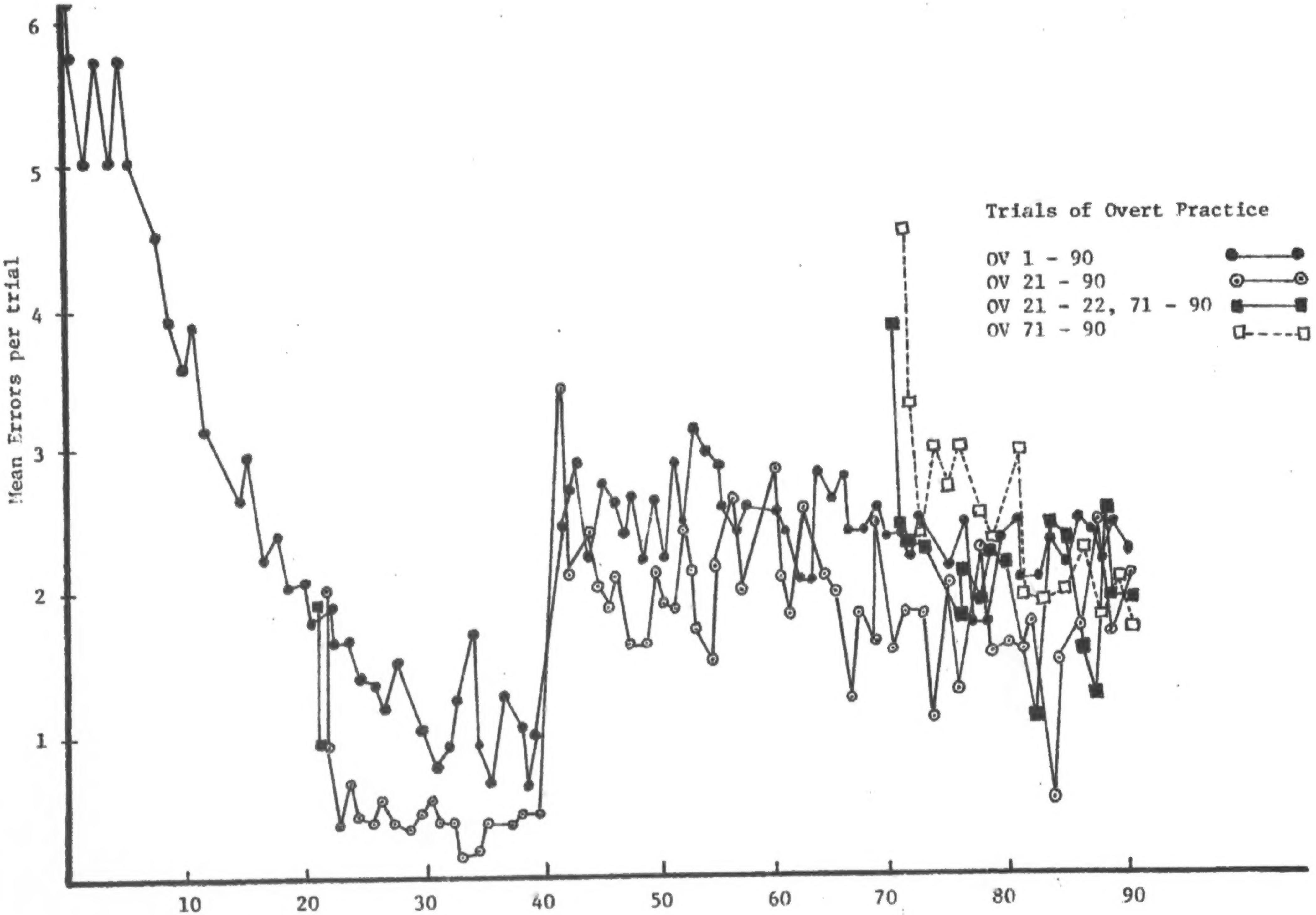


Fig. 9. Mean Errors for groups with varying amounts of prior overt and non-overt practice as a function of practice trials. Exp. V[illegible]

learned readily under non-overt practice conditions but a difficulty in accurately assessing the time requirements for the overt response is observed which is rapidly remedied. It seems unlikely that such a rapid change would be attributed to response learning that might be assumed to have occurred on these initial trials.

CONCLUSIONS, IMPLICATIONS AND RECOMMENDATIONS

This series of experiments was characterized by a set of highly similar tasks in terms of displays and required responses. The task consisted of associating arbitrary keyboard responses to single letter stimulus displays which were presented in a paired associate format. The task was selected to provide opportunity for response learning as well as association learning while requiring a minimum of stimulus discrimination. This combination of conditions seemed to provide experimental conditions to test various assumptions regarding the effect of overt and non-overt practice under a variety of practice and test conditions. In particular the question of the effects of variations in response mode under a variety of practice conditions was investigated.

The findings of the extended series of experiments can be interpreted to be consistent with the assumption that the overt practice response of the type used in these experiments has an interfering effect upon the acquisition stage of learning. The effect is characterized by occupying time that is more efficiently used under non-overt practice conditions. This interference effect was obtained only under restricted response interval conditions and this was particularly true when the POST RT or intertrial interval was reduced to the range of 1 sec. The interference was noted under conditions requiring both anticipation and prompted practice.

Interpretations of these data in terms of contiguity of stimulus terms as proposed by Cook & Spitzer (1960) and Stolurow & Lippert (1964) do not adequately account for the absence of interference under extended interstimulus interval conditions. On the other hand, the hypothesis selection model (Restle, 1962) if it is assumed that selection takes place only prior to the presentation of the response term (RT), does not account for the interfering effects associated with POST RT overt practice

If it were assumed that hypothesis selection might occur either before or after the RT event and that overt practice events might precede or follow the non-overt but critical hypothesis selection event but not simultaneously with it then more of the data could be accounted for.

Extending the PRE RT interval generally had less effect than extending the POST RT interval although the differences between these procedures was effectively eliminated when the extended interval was available on a variable schedule over trials. If overt practice responses interfere with the critical hypothesis selection event and this event occurs, at least during early trials of fixed interstimulus interval conditions, primarily during the POST RT interval then overt practice during this interval would seem to be maximally interfering. In this series of experiments this overt prompt condition showed no facilitating or interfering effects as a function of introducing overt practice responses except when the total POST RT interval was reduced to an absolute minimum. IT seems clear that the total time made ineffective by the occurrence of a prompted response is very small compared with the anticipation response. With highly practiced responses the occurrence of the response may have only slight or no interfering effect as is suggested by the failure of mere pronounciation of highly meaningful verbal items to interfere in the short-term memory context (Peterson & Peterson, 1959). It seems likely that it is again the non-overt pre-response behavior that is critical. Since this behavior is apparently extended in the case of anticipation practice, then there is more probability of interference with alternate hypothesis selection behavior.

In general the evidence from this series of experiments suggests that during the early trials the overtness of anticipation practice has little effect, either positive or negative, except to extend the length of the practice trial. As some learning occurs but correct anticipation responses are still characterized by extended latencies it seems that the interfering effect of PRE RT overt responses is increased since it may now interfere with appropriate but long latency anticipation responses. This interpretation is inconsistent with the one step conditioning model for conditioning strategies (Restle, 1962) since it introduces the phenomenon of decreasing latencies as a function of practice.

The data in the present series of experiments is by no means unambiguous on the matter of decreasing latencies during PRE acquisition phase. In attempting to determine the specific factors associated with PRE RT overt practice interference, Experiments IX and X were conducted. These experiments included procedures that attempted to control for such factors as possibly failing to make appropriate orienting responses in the presence of the stimulus term (ST), overlapping practice and ST intervals and violation of instructions regarding placement and movement of hands during interval. None of these controls altered the PRE RT interference effect.

The possibility that extending the anticipation interval provides additional time to encode the ST (Hunt, 1962) seems difficult to consider seriously in these studies since the ST events were highly discrete and meaningful single letters of the alphabet. The assumption that the overt practice response itself is interfering by directly interacting with contiguous stimulus and response events finds little or no support. This position encounters difficulties when one considers that by extending the anticipation interval no indication of interference is evident.

The general conclusion is that the overt practice response has no direct effect upon paired associate learning except to extend learning trials or to interfere if the response interval is minimal and if the following conditions are met. (1) the response is a member of a highly overlearned set such as meaningful verbal responses and (2) overtraining stages of practice are not considered. The effects noted seem to be independent of correctness of the response.

In contrast to the relatively neutrasl effects of the overt response the effects of moderately extending interstimulus intervals was found to be marked. This effect was found to be one of facilitating learning as the interval was extended. The interval effect was found to be reduced by introducing the extended intervals on a varying schedule. Under constant interval conditions it was found that the effect was facilitating primarily during the POST RT interval.

Making the interstimulus interval contingent upon the correctness of the preceding response had only a slight effect in that extending the interval following incorrect responses was slightly more effective than extending the interval following correct responses. However, the general depression of the interval effect related to introducing a variable interval length associated with a given stimulus pair under the correctness contingency was apparently much more severe than the slight difference obtained between the correct or incorrect contingency conditions.

The one positive effect of overt practice appeared in a rapid response overtraining task. The effects associated with prior non-overt practice were a temporary two trial failure to attempt responses followed by performances that equalled the groups with prior overt practice. This effect seemed most attributable to failure of the non-overt practice groups to acquire an appropriate estimate of the response time requirements rather than failure to acquire the required associations.

The implications of these findings are most obviously that parametric research is called for. The observation that apparently modest changes in the conditions associated with the interstimulus interval variable resulted in wide variations in effect upon acquisition. The parameters of the conditions affecting the interval variable must be much more clearly identified before predictions can be made with any confidence regarding optimal practice conditions. The same call for parametric research must be made regarding the effects of the overt practice response. It seems that the effects are subtle and indirect. Although the effects of the overt practice response may be described as being generally describable as being relatively neutral in the present series of studies unanswered questions remain regarding the source of interference and facilitation associated with overt practice under special conditions.

The studies making interval length contingent upon the correctness of the practice response raised a number of questions for further study. There seemed to be evidence that varying the intervals depressed the positive interval effect. Under what conditions can this depressing effect be removed? It was also possible to interpret one of the interactions as indicating that the easier lists benefitted relatively more from extended PRE RT while the harder ones from extended POST RT. These effects were all numerically small in the present studies but if better understood and controlled might result in effects sufficiently large to justify consideration in practical applications.

The present studies provide very little support for those who argue for responsive instructional enviornments. Under the conditions tested it seems that non-overt practice, combined with extended interstimulus intervals, particularly POST RT intervals which are constant and not dependent upon correctness of practice response are associated with optimal learning. This combination of conditions can be met by the simplest of display systems. The value of responsive systems such as those made possible by computer technology is not indicated in these studies. However, as previously indicated in the discussion there are indications that further research may provide parametric bases for such technological applications.

If these findings are generalizable to certain educational applications it might be informally observed that the findings tend to support the relatively simpler technological applications. Systems requiring and responsive to continuous practice responses are expensive and according to these findings ineffective or even interfering in the set of tasks resembling the present set. The finding which is most inconsistent with present instructional practice, especially in drill contexts is the finding regarding the relative effects of PRE RT and POST RT effects. Self determination of the practice cycle does not result in what appears to be the more efficient procedure of extending the POST RT and shortening the PRE RT intervals during acquisition. Instrumentation of the presentation sequence or perhaps some type of training directed at improving the strategies and tactics of efficient learning may be considered.

Although the set of tasks sampled in the present series of experiments was severely restricted and simple when contrasted with the vast range and variety of tasks that are of interest to the educator it became increasingly apparent over the course of the project that no general, invariable inferences regarding effects of manipulated variables were valid even in this relatively simple context. The general inference regarding the neutral effect of overt practice response had to be qualified to account for both the evidence of interference under short intervals and the evidence of facilitation during extended rapid practice. The general inference regarding the facilitating effect of extended interstimulus intervals similarly had to be qualified to account for the absence of PRE RT effect under concurrently extended POST RT conditions and the absence of extended S controlled practice interpolated between stimulus events.

This evidence of complex interrelationships argues anew for the need to continue programatic research which maintains reasonable controls and makes possible the investigation of complex interactions. An effective coherant theory of instruction can not be expected to arise from a body of studies which differ in unknown ways. The urgency imposed by a society that is eager to find remedies for the flagrant failures of the educational system must not lead to an abandonment of the painstaking analysis of school-related learning behaviors in the laboratory context even though it has so little face validity when contrasted with dramatic but often intuitive applications of technology to immediately pressing educational problems.

SUMMARY

This series of twenty paired associate experiments was designed to investigate the effects upon acquisition of verying the overtness of practice and the duration of the practice intervals. The task required the emission of practice response consisting of pressing a subset of three keys, selected from an array of seven irregularly positioned keys, that was paired with each of the single letter stimulus elements. The experiments were controlled and results recorded automatically.

The assumption that the overt practice of highly overlearned verbal or simple motor responses has an essentially neutral, time-consuming effect upon acquiring associations to paired stimuli was not disconfirmed. Maintanence of this neutral effect assumption, however, required that results indicating interference effects associated with overt practice during restricted interstimulus intervals be interpreted, for example, in terms of interference with non-overt activity required for establishing associations. The neutral effect assumption also required that the temporary interfering effect of non-overt practice found under rapid overtraining conditions be interpreted possibly in terms of added information feedback regarding temporal constraints available under overt practice conditions.

In contrast to the relatively neutral effect of the overt practice response, extension of the unfilled interstimulus intervals and particularly the extension of the inter-trial interval had a marked positive effect upon acquisition. This effect was found to diminish under variable interval conditions imposed by making the interval duration contigent upon correctness of practice response. Under constant interval conditions the effect was most evident when the inter-trial intervals was extended and least evident when the anticipation interval was extended.

The findings were discussed in terms of models that include implicit responses assumptions.

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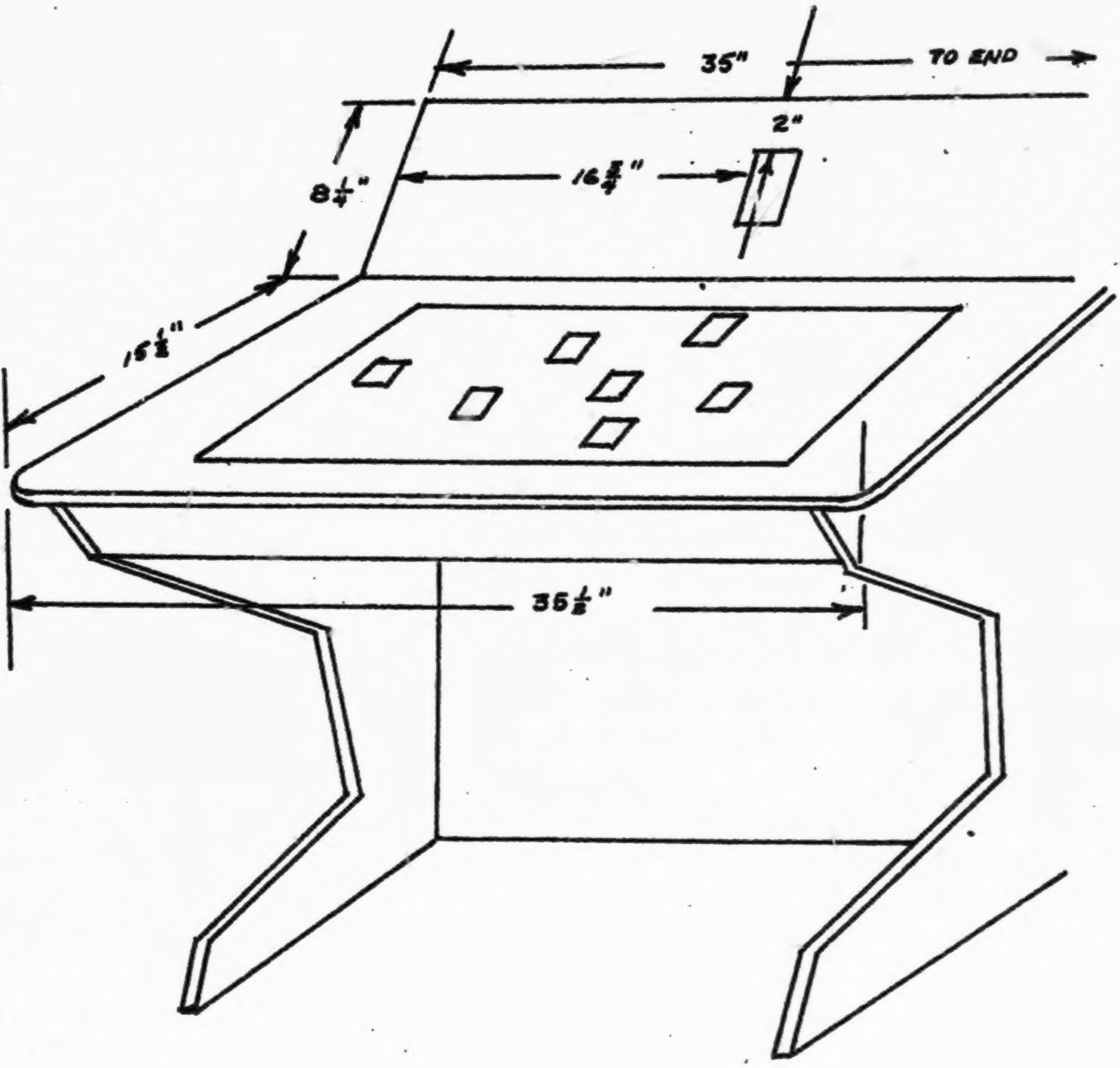
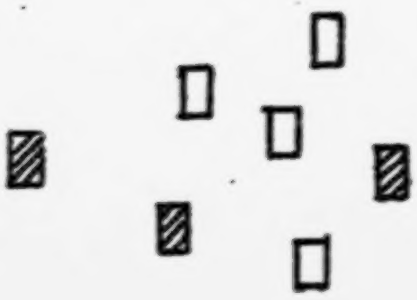
Appendix A, Part 1

Dimensions for Location of Response Buttons on Desk Surface

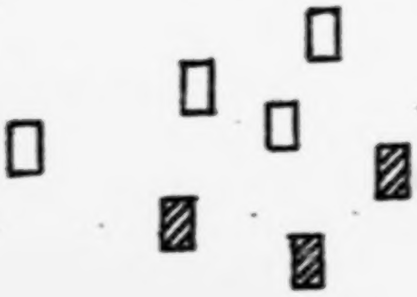

35"
TO END
2"
8¼"
16¾"
15½"
35½"

Appendix A, Part 2

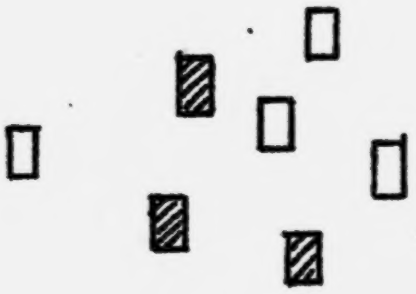
Stimuli and Associated Switch Patterns



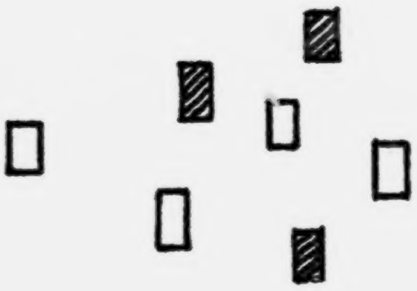
"Z"



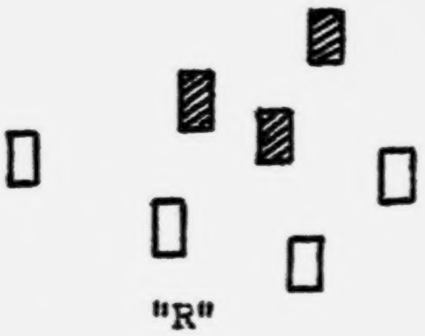
"Y"



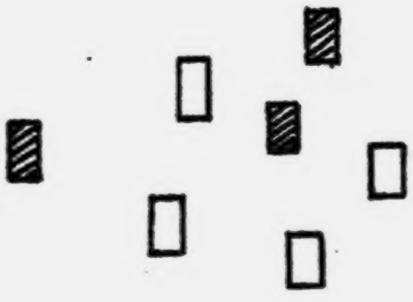
"F"



"E"



"R"



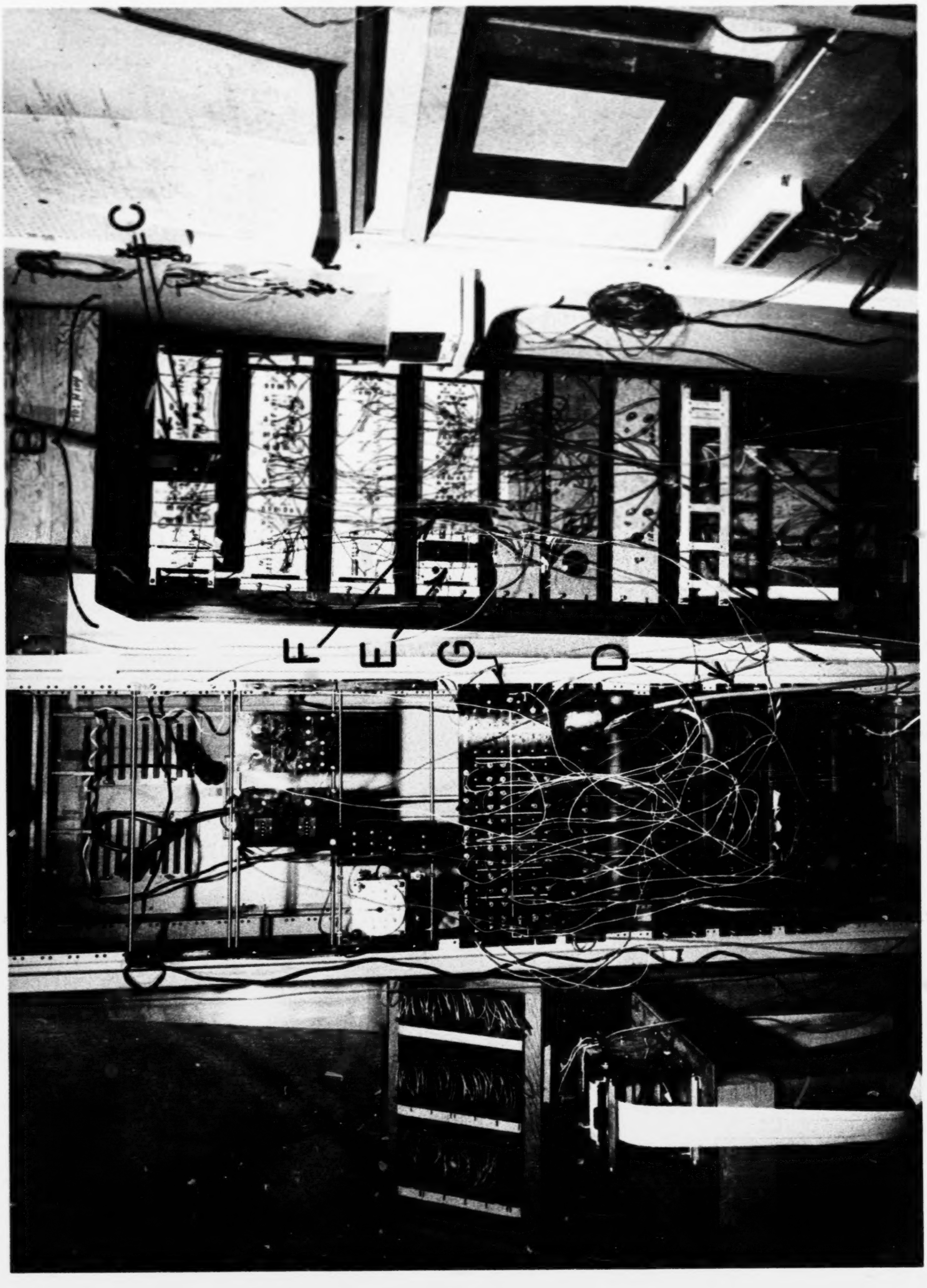
"L"

▨ lighted switch

☐ unlighted switch

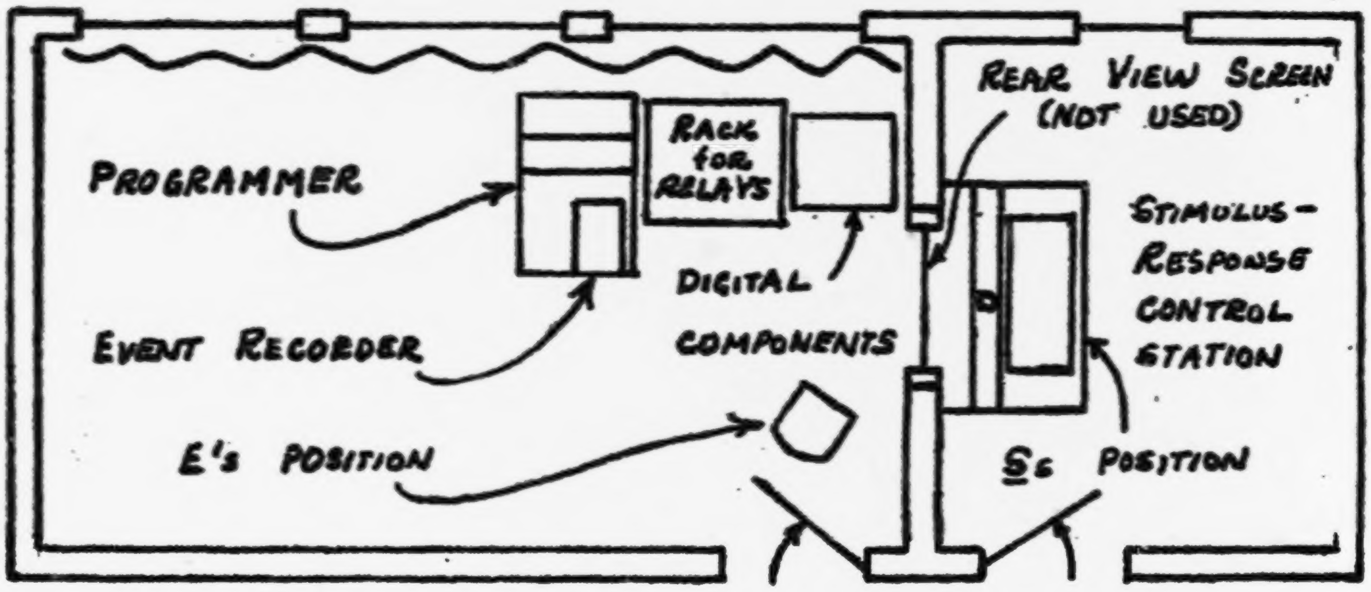
Appendix A, Part 3

Control Apparatus, Experiments I & II



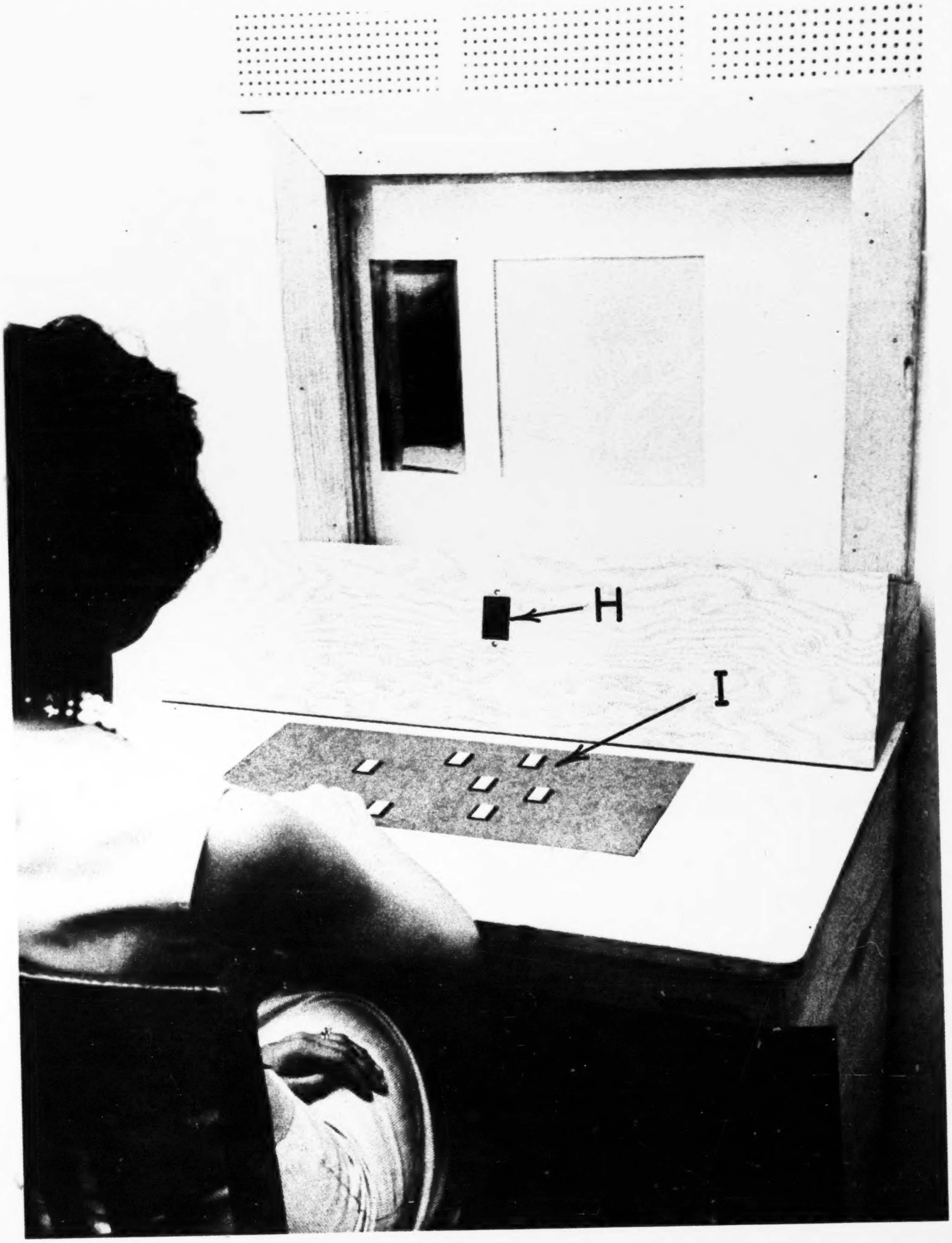
Appendix A, Part 4

Floor Plan of the Laboratory, Experiments I & II


PROGRAMMER
RACK FOR RELAYS
REAR VIEW SCREEN (NOT USED)
STIMULUS-RESPONSE CONTROL STATION
DIGITAL COMPONENTS
EVENT RECORDER
E's POSITION
S's POSITION

Appendix A, Part 5

Stimulus Response Station of Apparatus, Experiments I & II



Appendix A, Part 6

Mean Error Scores on Paired Associate Task for Experiment I

		POST RT Interval			
		1 sec.	5 sec.	9 sec.	PRE RT Means
PRE RT Intervals	0 sec.	8.5	4.0	8.0	6.8
	4 sec.	9.0	4.5	2.5	5.3
	8 sec.	5.5	8.0	2.0	5.2
POST RT Means		7.7	5.5	4.2	5.8

Appendix A, Part 7

Mean Error Scores on Paired Associate Task for Experiment I

		POST RT Interval			
		1 sec.	5 sec.	9 sec.	PRE RT Means
PRE RT Intervals	0 sec.	9.3	4.0	.8	4.7
	4 sec.	8.3	4.8	3.8	5.6
	8 sec.	10.0	1.8	1.8	4.5
POST RT Means		9.2	3.5	2.1	4.9

Appendix B, Part 1

Mean Error Scores for Interval and Practice Mode Conditions in Experiment III

POST RT

Practice Mode	1 sec. PRE RT 0 sec.	1 sec. PRE RT 4 sec.	5 sec. PRE RT 0 sec.	5 sec. PRE RT 4 sec.	Practice Mode Means
OV	28.0	12.5	7.5	5.5	13.4
S-OV	17.0	11.5	8.5	11.5	12.1
N-OV	17.5	6.0	5.5	11.5	11.4
Interval Means	20.8	10.0	7.2	9.5	11.9

Appendix B, Part 2

Analysis of Variance of Total Errors as a Function of Practice Mode, PRE Response Term, and POST Response Term Intervals in Exp. III.

Source	df	f
Practice Mode (M)	2	.74
PRE Response Term Interval (PRE RT)	1	3.74
POST Response Term Interval (POST RT)	1	10.37*
PRE RT x POST RT	1	8.95**
PRE RT x M	2	1.08
POST RT x M	2	2.14
PRE RT x POST RT x M	2	.35
Residual	12	-

* p < .01
**p < .05

Appendix C, Part 1

Mean Error Scores for Interval and Practice Mode Conditions in Experiment III

POST RT

	1 sec.		5 sec.		
	PRE RT		PRE RT		
Practice Mode	0 sec.	4 sec.	0 sec.	4 sec.	Practice Mode Means
OV	24.5	11.0	3.0	10.5	12.3
S-OV	6.5	12.0	8.5	8.5	17.5
N-OV	4.0	16.0	6.5	7.0	16.8
Interval Means	11.7	13.0	6.0	8.5	15.5

Appendix C, Part 2

Analysis of Variance of Total Errors as a Function of Practice Mode, PRE Response Term, and POST Response Term Intervals in Exp. IV.

Source	df	f
Practice Mode (M)	2	1.51
PRE Response Term Interval (PRE RT)	1	.91
POST Response Term Interval (POST RT)	1	6.40*
PRE RT x POST RT	1	.08
PRE RT x M	2	1.79
POST RT x M	2	2.27
PRE RT x POST RT x M	2	6.27*
Residual	12	-

$*p < .05$

Appendix D, Part 1

Mean Error Scores for Interval and Practice Mode Conditions in Experiment V

POST RT

	1 sec.		5 sec.		
	PRE RT		PRE RT		
Practice Mode	0 sec.	4 sec.	0 sec.	4 sec.	Practice Mode Means
OV	11.0	6.0	4.6	1.8	5.9
S-OV	6.1	8.3	4.0	2.9	5.3
N-OV	14.5	9.0	5.4	3.3	8.1
Interval Means	10.5	7.8	4.7	2.7	6.4

Appendix D, Part 2

Analysis of Variance of Total Errors as a Function of Practice Mode, PRE Response Term, and POST Response Term Intervals in Exp. V.

Source	df	f
Practice Mode (M)	2	1.25
PRE Response Term Interval (PRE RT)	1	2.53
POST Response Term Interval (POST RT)	1	13.21*
Block (Native English)	1	12.36*
PRE RT x POST RT	1	.07
PRE RT x M	2	.92
POST RT x M	2	.49
PRE RT x POST RT x M	2	.47
Residual	83	-

* p < .001

Appendix E

Instructions, Experiment VII

Please put your things on this chair (IF S IS CARRYING ANYTHING) and be seated here. (MAKE SURE S IS FACING CONSOLE SQUARELY AND COMFORTABLY.) You will be instructed on the intercom when to press the keys in front of you. When you press them you are to use both hands as you would if you were typing with one finger of each hand, making sure to press only one key at a time to avoid jamming the keys. Will you please press three keys now using two hands in typewriter fashion? (MAKE SURE S MAKES APPROPRIATE RESPONSE.) The rest of the instructions will be presented on the intercom. (LEAVE THE ROOM.) Can you hear me clearly? (MAKE SURE S HEARS CLEARLY.)

You will first be shown a letter of the alphabet projected on the little black screen in front of you. Shortly afterwards signal lights will tell you which three keys go with that particular letter. Other letter-key pairs will be presented and your task is to remember which three keys follow each letter. You are told how to practice by the color of the light signal. You may think of green as meaning "go" or "press keys" and red meaning "stop" or "practice to yourself". So when either the light on the screen is red or the keys are red you are to practice by watching only and trying to remember the letter-key combination. You are not to move your hands or press the keys when a red light is on. When the color on either the screen or the keys is green you are to practice by pressing the three keys you think are associated with the letter you have just seen. You will have to guess at first but you will soon be able to press the correct three keys every time the color is green. Remember that you are to press the keys in typewriter fashion using two hands and pressing one key at a time. If one of the keys sticks, push it again rapidly and it will be released.

Now let us go slowly through an example: (RED) The red light on the screen means observe, but hands must remain motionless. (LETTER + RED) The letter on the red background means try to guess to yourself or later remember which three keys go with that letter but continue to keep your hands motionless. (RED KEYS) A red signal on the keys also means to observe, try to remember, but keep the hands motionless. (RED KEYS + SIGNAL LIGHT) The signal light tells you which three keys go with the immediately preceding letter and since the keys are red you just observe. So, when the letter is presented on a red screen you just observe and try to guess the correct three keys but you do not press the keys or move your hands. If the keys are later lighted up red you notice the three keys indicated by the signal lights but do not press the keys or move your hands.

(GREEN) In the next example the screen is green which means get ready to press the keys as soon as you see the letter. (GREEN + LETTER) You now see the letter and since the background is green, you are to press the three keys as soon as you can. You will have to guess at first since you have not yet seen the signal lights. It is very important that you press three keys every time the letter appears on a green background even if you have to guess at first. Please select three keys now and press them since the background is green. (MAKE SURE S PRESSES THREE KEYS BEFORE GOING ON.) (RED KEYS) The keys below are red meaning that you will review to yourself, but you will not press the keys again since the keys are red. You see the correct three keys indicated by the signal light. (SIGNAL LIGHT + RED) You now see the three keys that go with the preceding letter but since the keys are red you just watch and keep your hands motionless.

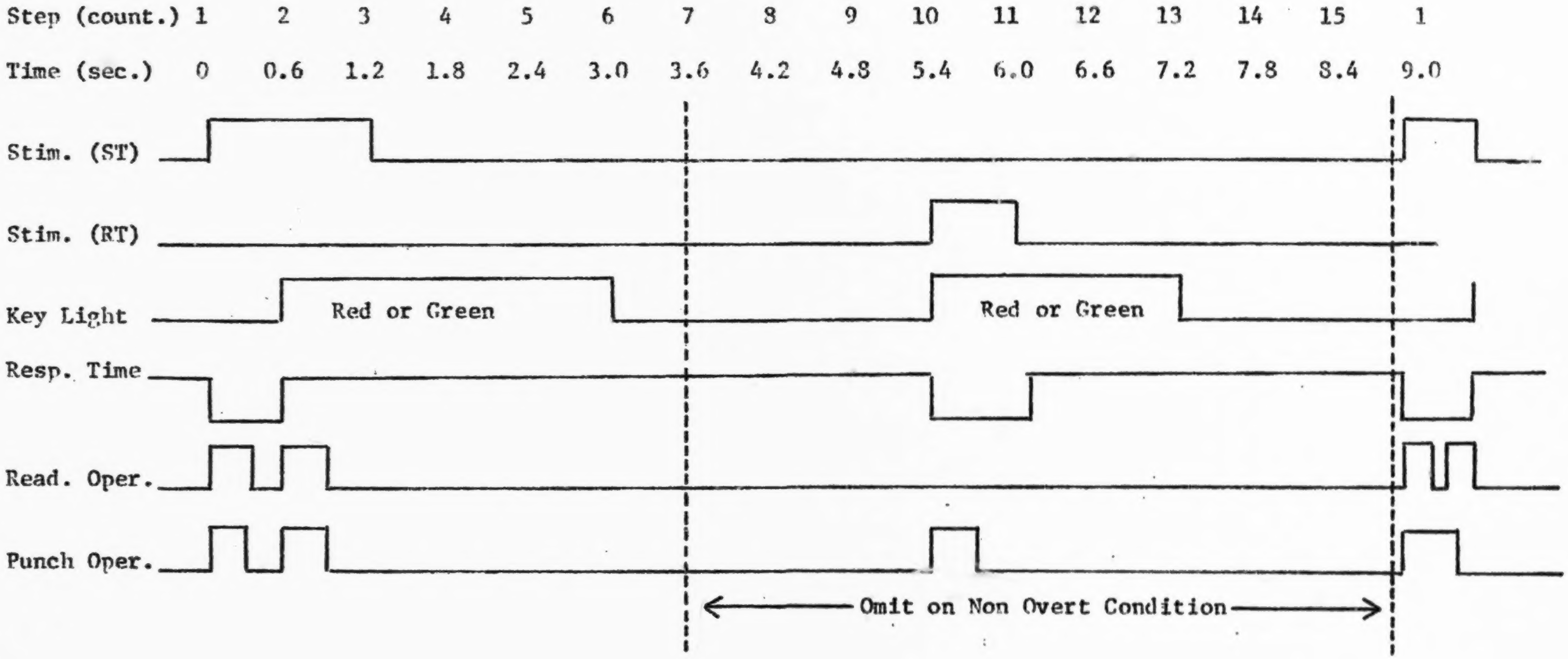
(RED) In this example the screen is red meaning get ready to observe but you will not press the keys or move your hands. (RED + LETTER) You now see the letter but since it is on a red background you just think to yourself about the keys associated with it, but do not press the keys. (GREEN KEYS) Green keys mean get ready to review the three keys by pressing them as soon as they are indicated. (GREEN KEYS + SIGNAL LIGHTS) You now see which three keys go with the preceding letter so since the keys are green you are to press the keys. Please press them now. (MAKE SURE THAT S DOES SO)

Please take a minute to rest and stretch now before we begin the next task [change tapes]. Now, please be seated. In the next task there will be a new set of letter-key combinations to learn. You are to follow the same instructions as before. Remember, to be sure to guess by pressing the keys everytime the go light is on even if you have to guess at first. Are you ready?

There is one more very short part left. Before we begin the last part, please take a minute to relax. [change tapes] In the last part you will have the same letter-key pairs as you have just had. This time you are asked to see if you can increase your speed in pressing the keys. You may press the keys just as soon as you see the letter. Remember, that you are to use both hands but press only one key at a time as in typing. So continue to press the right keys as you try to increase your key pressing speed. Are you ready?

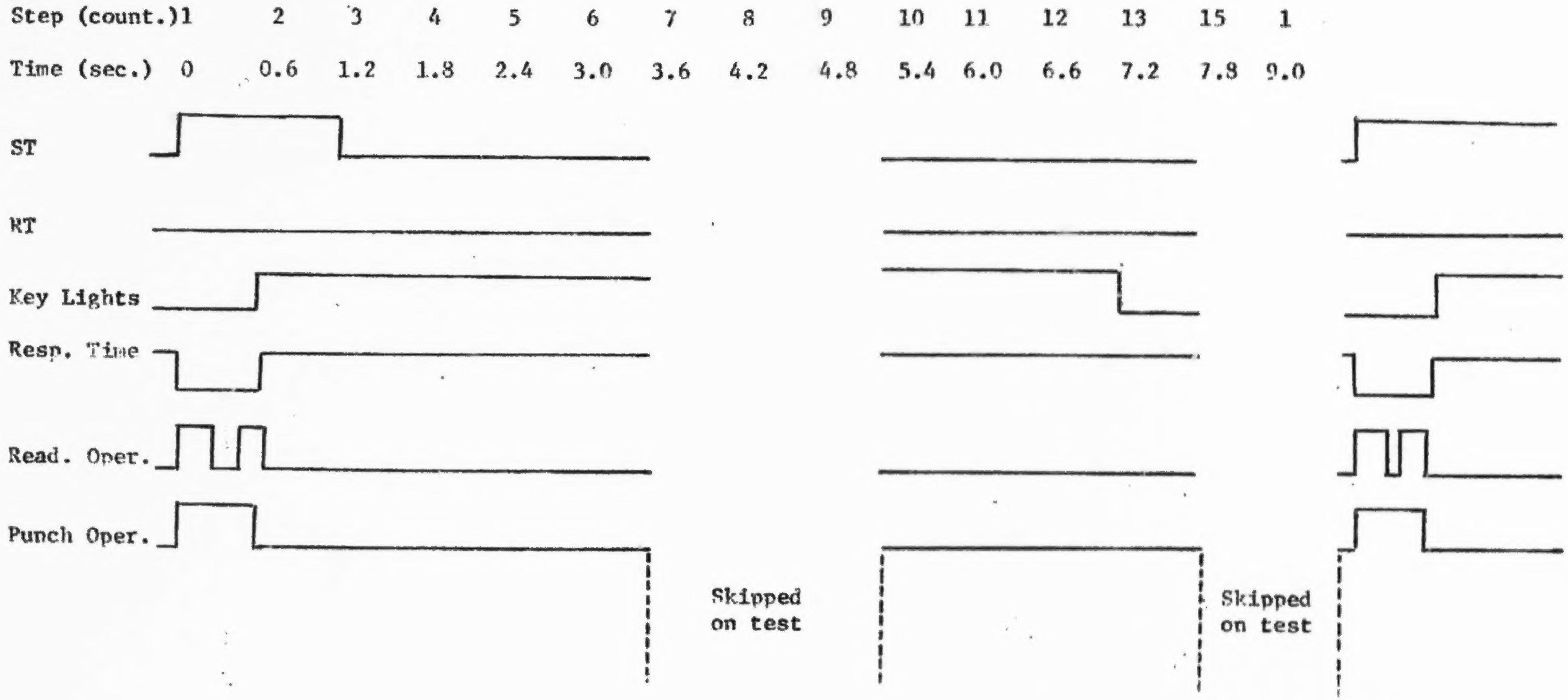
Appendix F, Part 1

Practice Time Line, Experiment VIII


Step (count.) 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 1
Time (sec.) 0 0.6 1.2 1.8 2.4 3.0 3.6 4.2 4.8 5.4 6.0 6.6 7.2 7.8 8.4 9.0
Stim. (ST)
Stim. (RT)
Key Light
Red or Green
Red or Green
Resp. Time
Read. Oper.
Punch Oper.
Omit on Non Overt Condition

Appendix F. Part 2

Test Time Line, Experiment VIII


Step (count.) 1 2 3 4 5 6 7 8 9 10 11 12 13 15 1
Time (sec.) 0 0.6 1.2 1.8 2.4 3.0 3.6 4.2 4.8 5.4 6.0 6.6 7.2 7.8 9.0
ST
RT
Key Lights
Resp. Time
Read. Oper.
Punch Oper.
Skipped on test
Skipped on test

Appendix F, Part 3

Instructions for OO Condition in G

Experiment VIII

You will first see a letter appear in the little black screen like this (PRESENT O). Then the keys below will light up red like this (KEYS RED) telling you to practice by thinking quietly of the three keys that you think might go with the letter O. You will have to guess at first, of course. It is important that you sit quietly and think of the three keys whenever the keys are red. If you forget and start to press the keys while the keys are red, the tone will be sounded and the sign reminding you to think quietly will come on like this (SOUND TONE AND ILLUMINATE THINK SIGN). Next the three keys that go with the letter O will be indicated by the little lights just above the keys like this (PRESENT O-RT). You should try to remember that the three keys that were just indicated by the little lights always go with the letter O. Notice that the keys are red. This indicates that you are to practice the three keys that go with the letter O by thinking quietly of the three keys now.

You will now see another letter which is associated with a different set of three keys (PRESENT R). Just as before the keys are red, telling you to think quietly of the three keys that go with the letter R (PRESENT R-RT). Now you see the three keys that go with the letter R. And, just as before, the keys are always red after the three keys are indicated telling you to think quietly of the three keys that go with the letter R.

You will now see a new letter (PRESENT S) and you will follow the same practice procedure that you used with the other two letters. You first try to guess the three keys, thinking quietly of the correct keys (PRESENT S_RT). Now you will see the same three pairs of letters and key patterns in a different order. Continue to practice as before. If you forget and start to press the keys when the keys are red, you will be reminded to think quietly like this (TONE-SIGN). (PRESENT R-O-S) at slow pace. Observe S closely and if he moves his hands over the response panel during red period or if he makes obvious tracing movements of over 1" during red period press signal. If any procedural errors were made, repeat briefly at end of cycle, "Remember that after you see the key pattern and the keys are red, you should practice by sitting quietly and thinking of the correct set of three keys."

The same three pairs of letters and key patterns will be presented in a different order but this time they will appear at the regular pace. Try to keep up and continue practicing just as you have been (PRESENT O-S-R).

Now you will have a review test. This time the letters will be presented and the keys will be lighted green indicating that you are to press the three keys that go with each letter. During the review test you will be shown the letter but not the correct pattern.

(PRESENT TEST R-S-O).....

That is the end of the introductory practice. You will now learn a new set of letter-key combinations which includes new letters and key patterns. You are to practice exactly as before and you will be tested as before. However, since the list is longer you will be given practice again after each test until you can press the correct keys every time without error.

Remember, you are to think quietly of the letter-key combination when the red keys appear, and to think quietly of the three keys that go with the letter after the correct keys are indicated. If you forget to think quietly, you will be reminded by the tone and seeing the red "think" sign. Are there any questions?

We will start at the normal faster rate, so it may be hard to guess fast enough at first, but try hard to guess and to think quietly about the correct keys when the keys are red and press the keys when they are green.

Are you ready?

Appendix F, Part 4

Analysis of Variance of Errors as a Function of Practice Mode, PRE Response Term, and POST Response Term Intervals in Exp. VIII.

Source	df	f
Blocks	2	19.92*
Instructions (I)	1	-
PRE Response Term Interval (PRE RT)	1	15.18*
POST Response Term Interval (POST RT)	1	4.58
I x PRE RT	1	-
I x POST RT	1	-
PRE RT x POST RT	1	-
PRE RT x POST RT x I	1	-
Residual	118	-

* $p < .01$

Appendix G, Part 1

Summary of Serial Order and PRE RT Interval Characteristics of Stimulus Pairs in Experiment IX.

Key: S = short or 0 sec. PRE RT interval
L = long of 4 sec. PRE RT interval
Numeral subscript as SL_6 = stimulus-response term pair
Numeral only (1 - 8) = test trial
SL_6, LL_2, etc. = practice trial

Practice-test cycles

SL_6	LL_2	LS_3	SS_8	SS_7	SL_5	LL_1	LS_4
SL_5	LL_2	LL_1	LS_3	SL_6	LS_4	SS_8	SS_7
5	2	8	3	1	6	4	7
LS_3	SS_7	SS_8	SL_5	LS_4	SL_6	LL_2	LL_1
LS_3	SS_7	SL_6	LL_1	LL2	LS_4	SS_8	SL_5
4	2	1	3	6	8	5	7
SL_5	LL_1	LS_4	SS_8	SS_7	SL_6	LL_2	LS_3
SS_7	SL5	LL_2	LS_3	SL_5	LL_1	LS4	SS_8
2	5	3	8	1	4	7	6
LS_4	SS_8	SL_5	LL_2	LS_3	SS_7	SL_6	LL_1
LS_3	SS_8	SL_6	LL_2	LL_1	LS_4	SS_7	SL_5
6	2	8	7	4	3	5	1

Blocks x Pairs (counterbalance unequal pair difficulty)

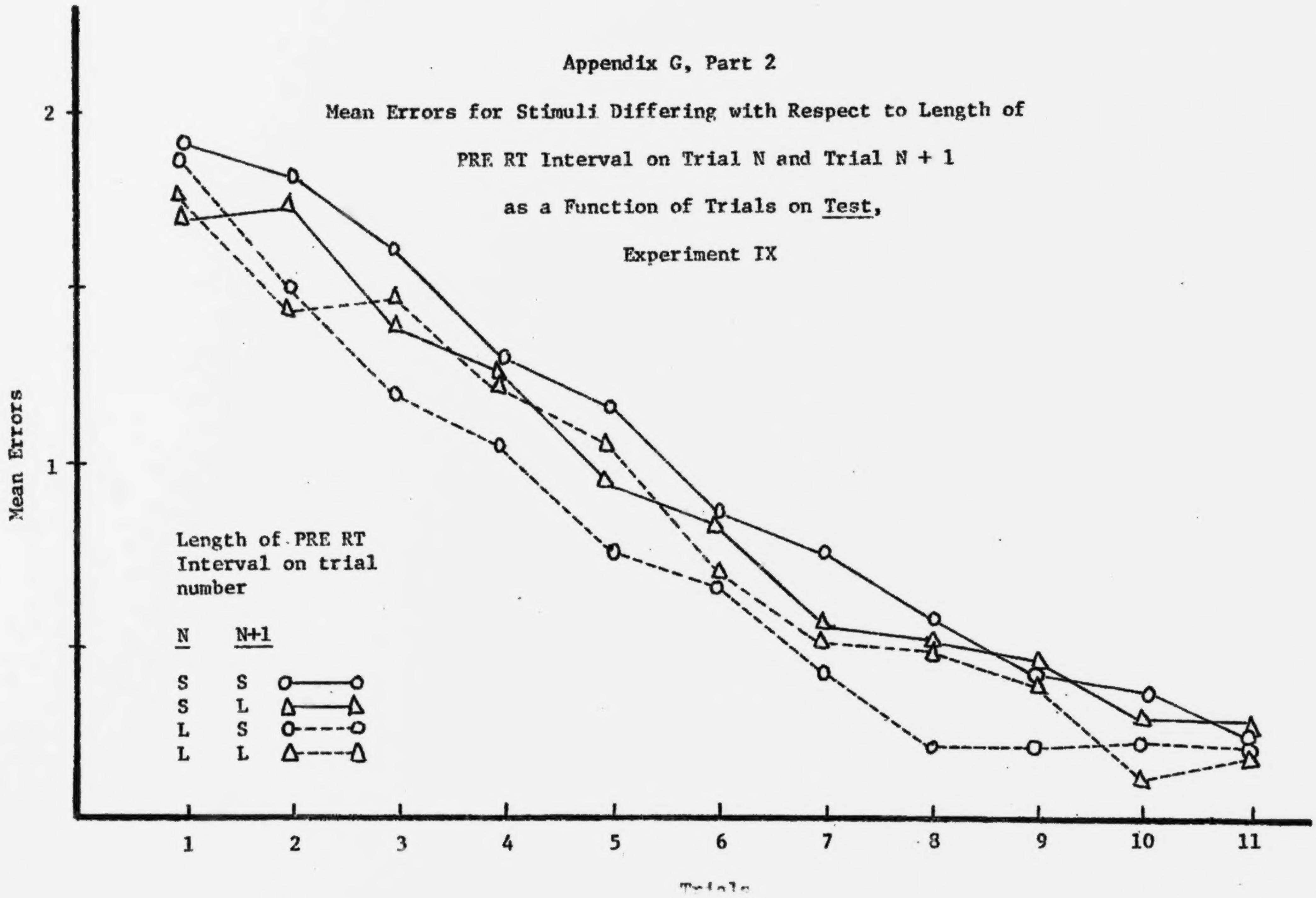
Pairs	Blocks I	II	III	IV
1	LL	SS	SL	LS
2	LL	SS	SL	LS
3	LS	LL	SS	SL
4	LS	LL	SS	SL

Pairs	Blocks I	II	III	IV
5	SL	LS	LL	SS
6	SL	LS	LL	SS
7	SS	SL	LS	LL
8	SS	SL	LS	LL

Appendix G, Part 2

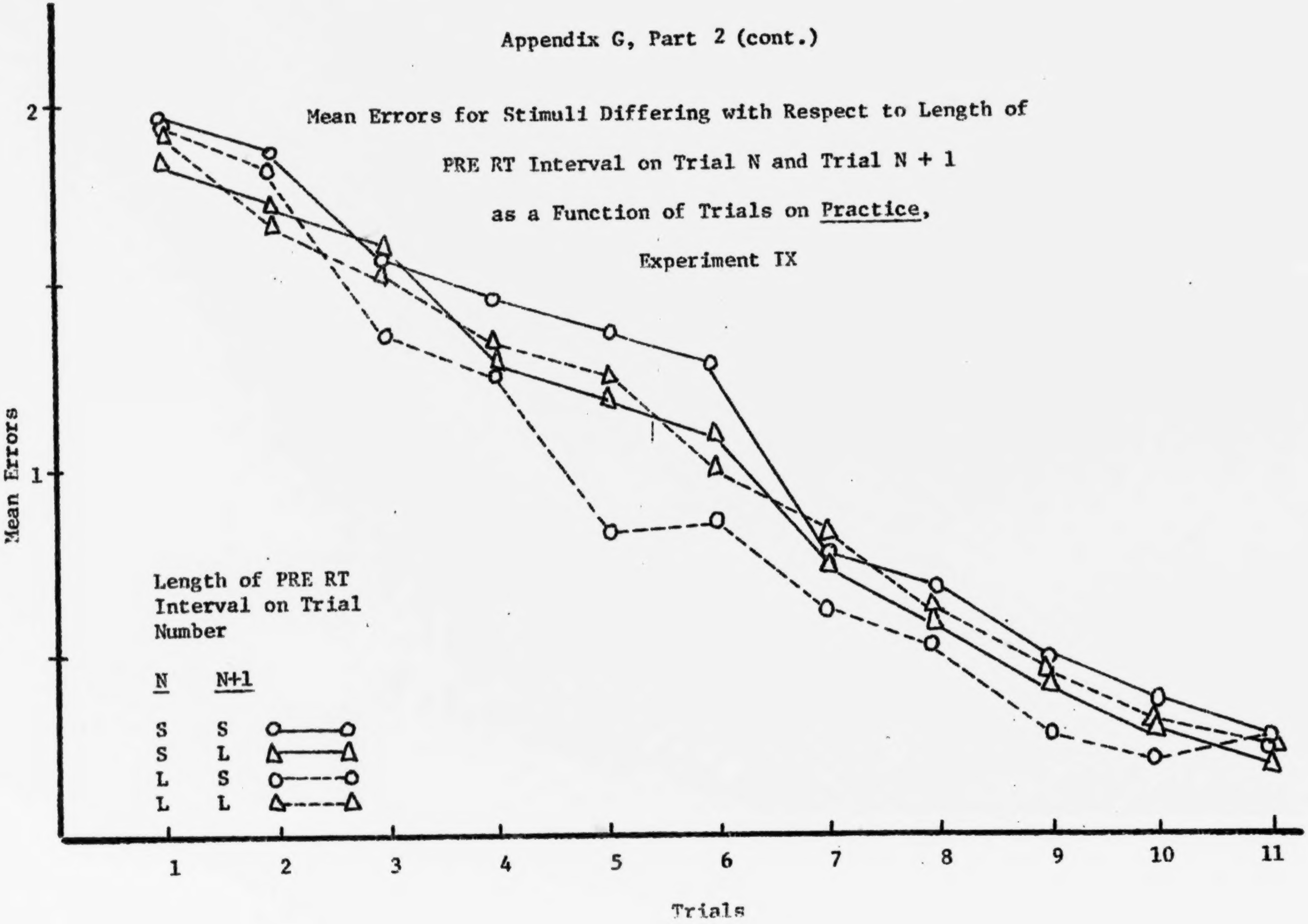
Mean Errors for Stimuli Differing with Respect to Length of PRE RT Interval on Trial N and Trial N + 1 as a Function of Trials on Test,

Experiment IX



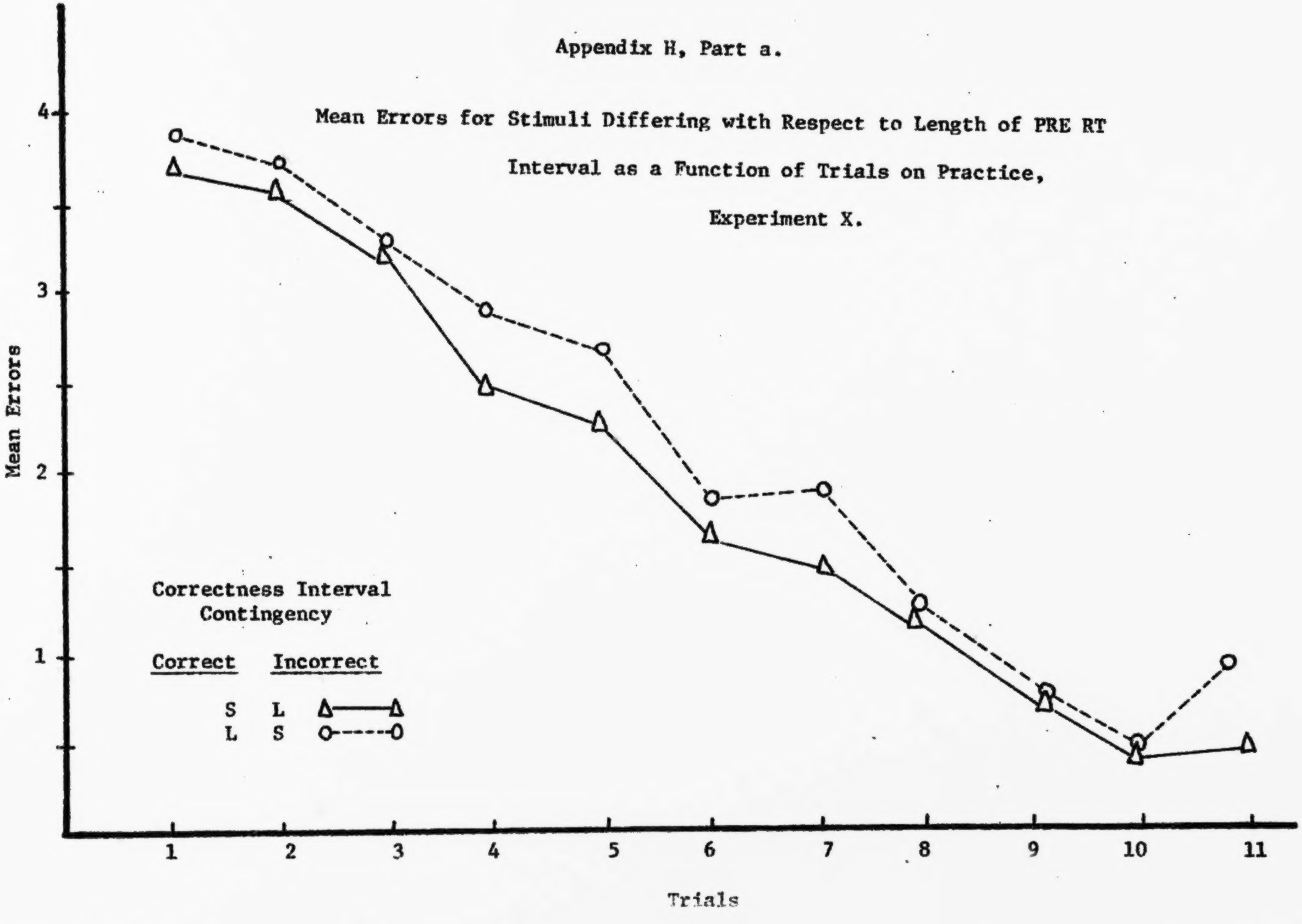
Appendix G, Part 2 (cont.)

Mean Errors for Stimuli Differing with Respect to Length of PRE RT Interval on Trial N and Trial N + 1 as a Function of Trials on *Practice*, Experiment IX



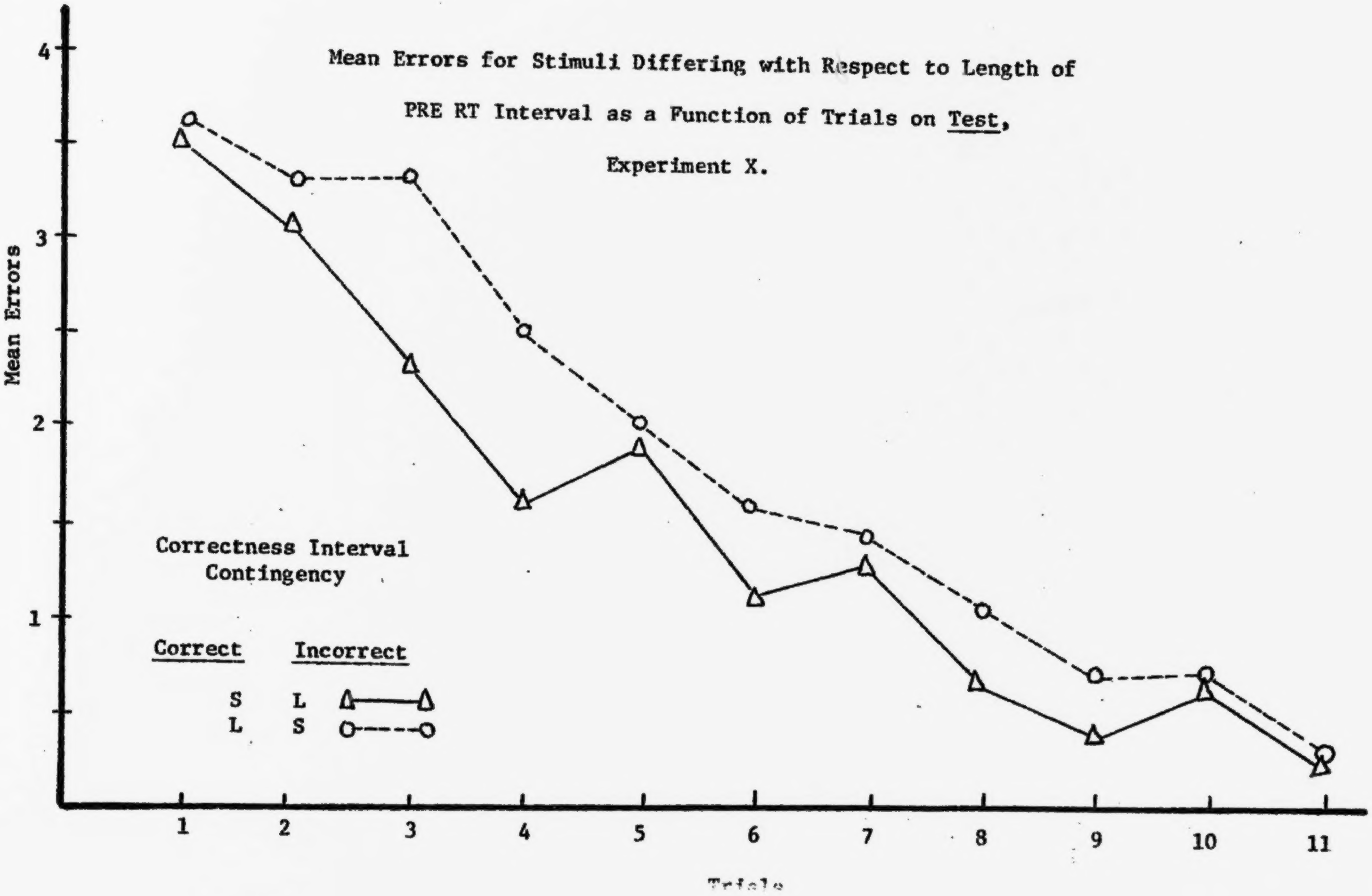
Appendix H, Part a.

Mean Errors for Stimuli Differing with Respect to Length of PRE RT Interval as a Function of Trials on Practice, Experiment X.



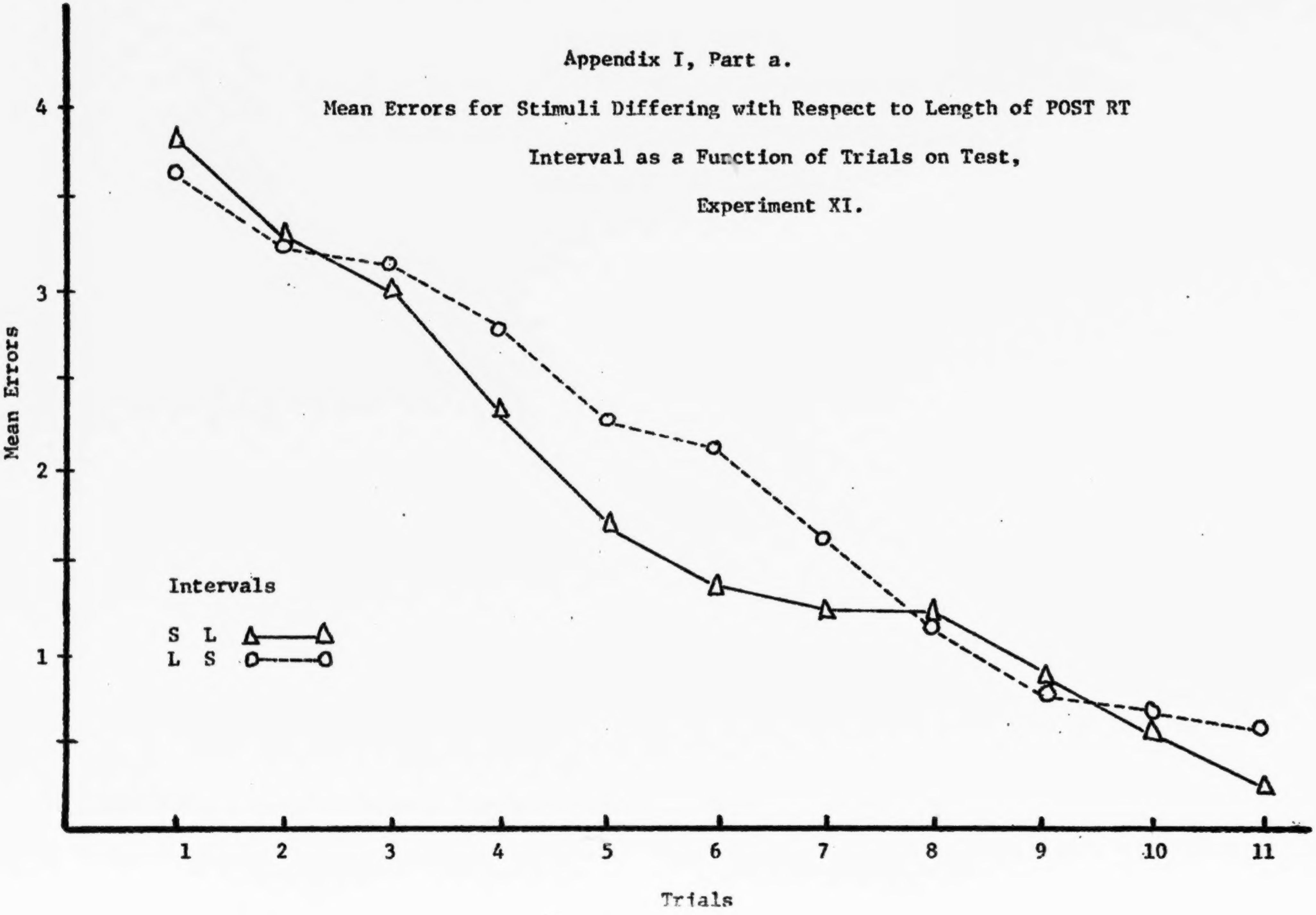
Appendix H, Part b.

Mean Errors for Stimuli Differing with Respect to Length of PRE RT Interval as a Function of Trials on Test, Experiment X.



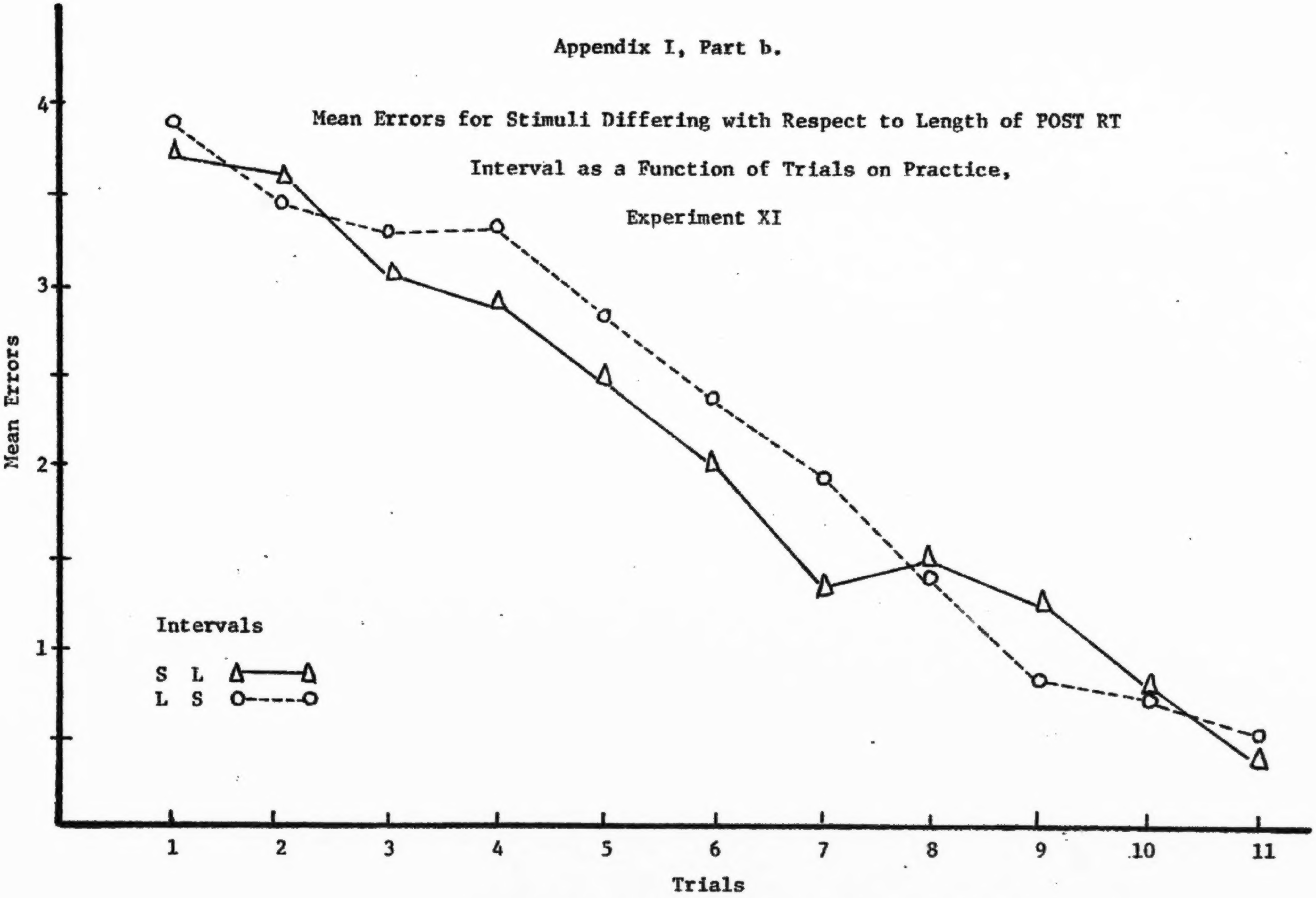
Appendix I, Part a.

Mean Errors for Stimuli Differing with Respect to Length of POST RT Interval as a Function of Trials on Test, Experiment XI.



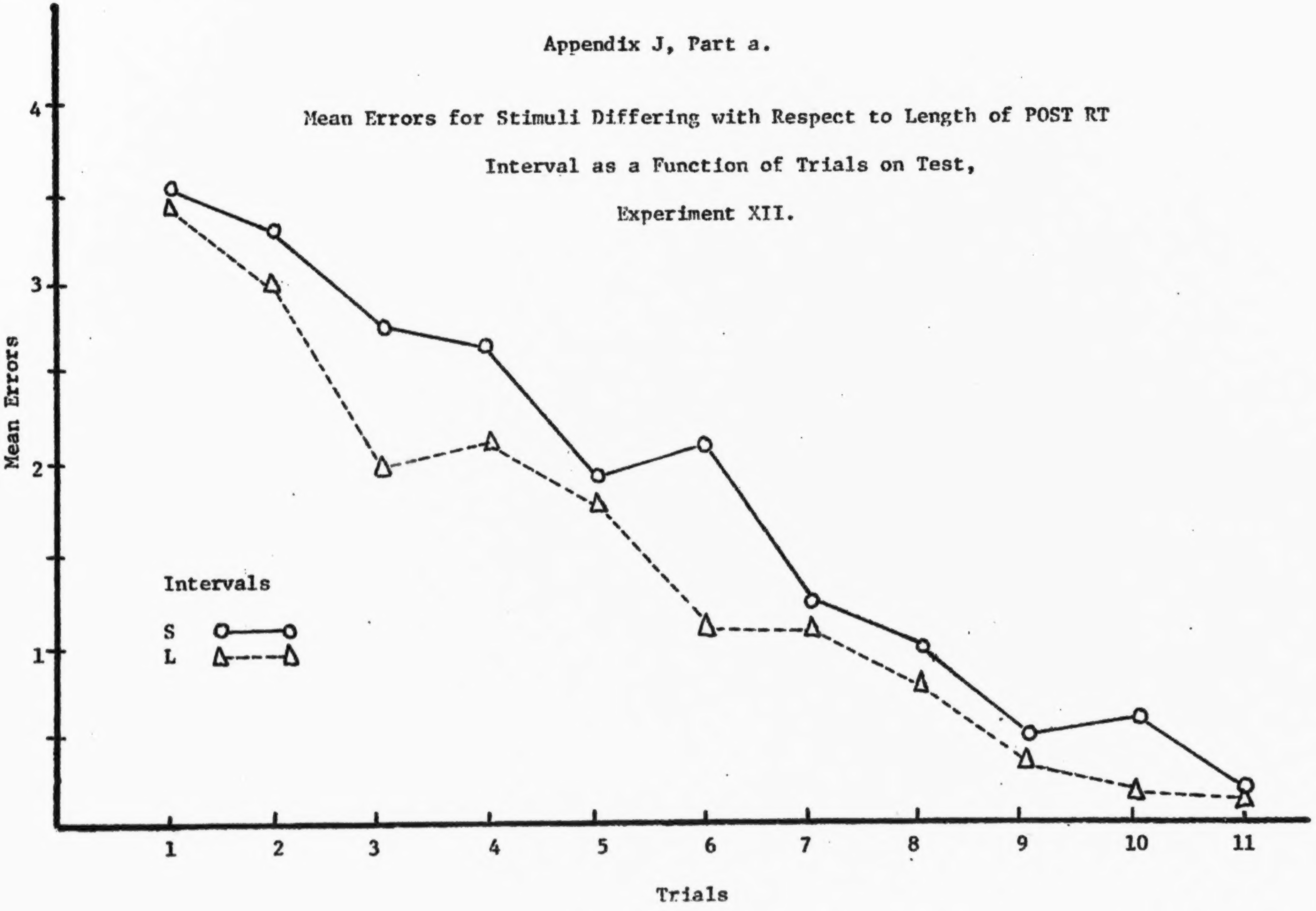
Appendix I, Part b.

Mean Errors for Stimuli Differing with Respect to Length of POST RT Interval as a Function of Trials on Practice, Experiment XI



Appendix J, Part a.

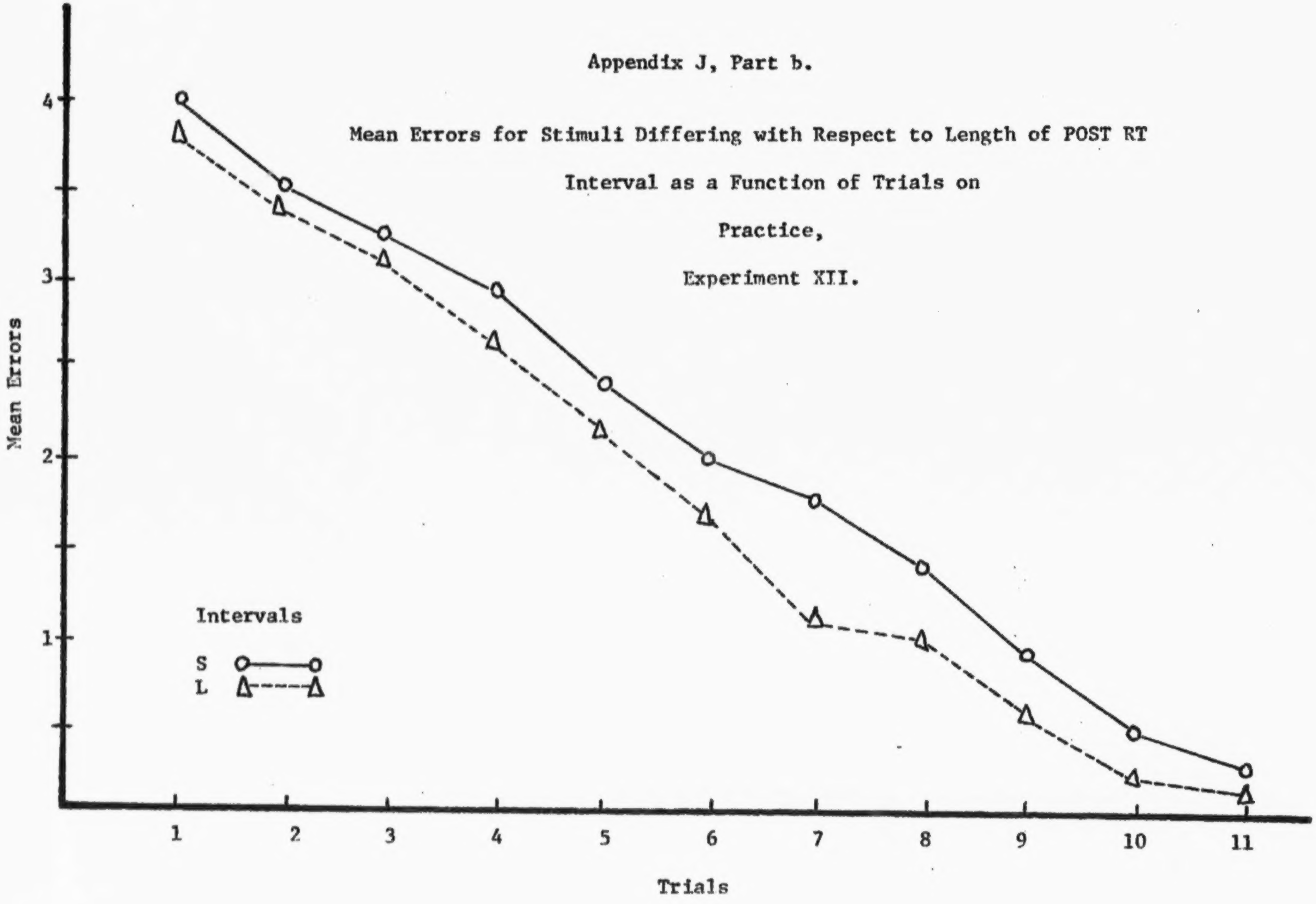
Mean Errors for Stimuli Differing with Respect to Length of POST RT Interval as a Function of Trials on Test, Experiment XII.



Appendix J, Part b.

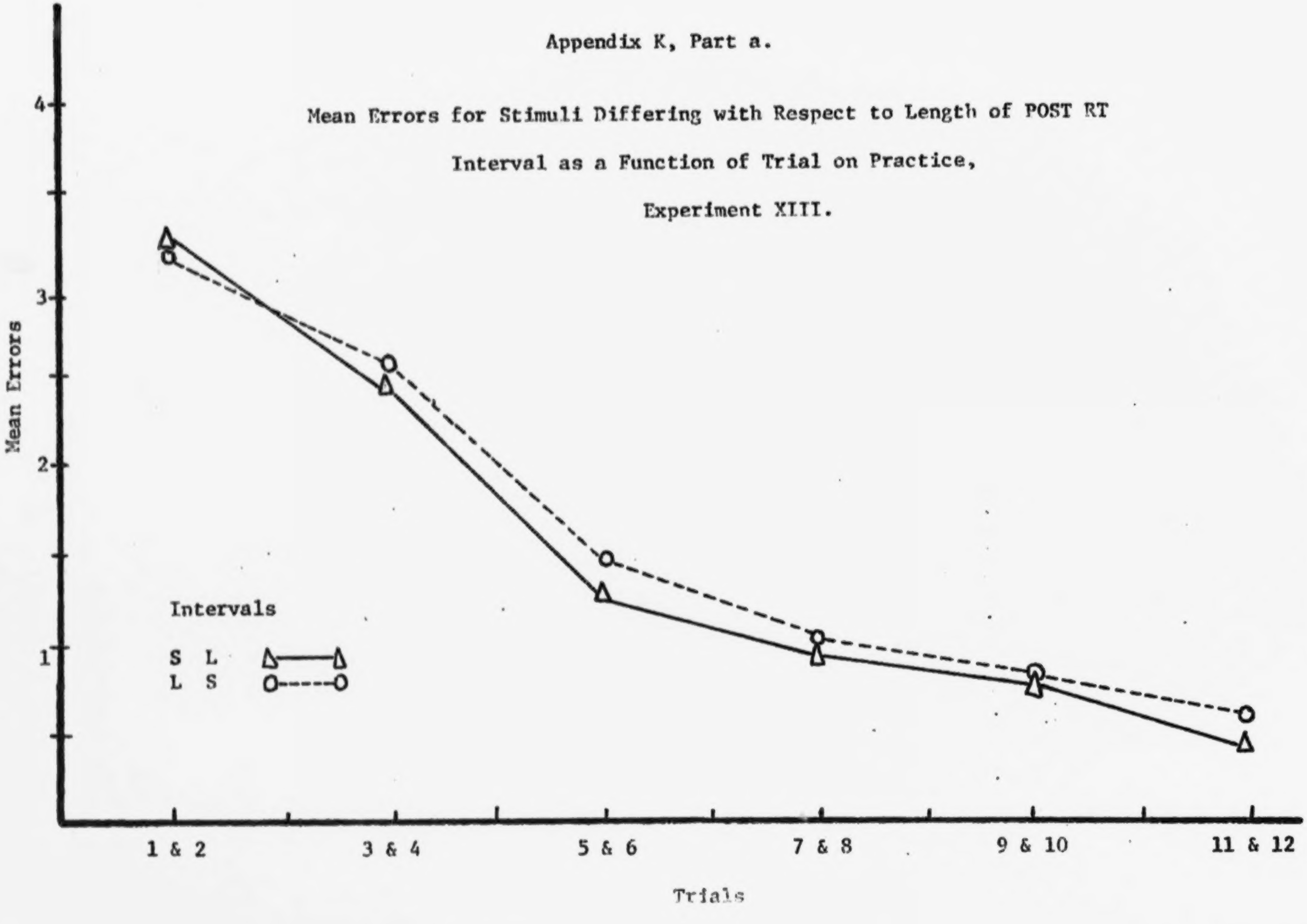
Mean Errors for Stimuli Differing with Respect to Length of POST RT Interval as a Function of Trials on Practice,

Experiment XII.



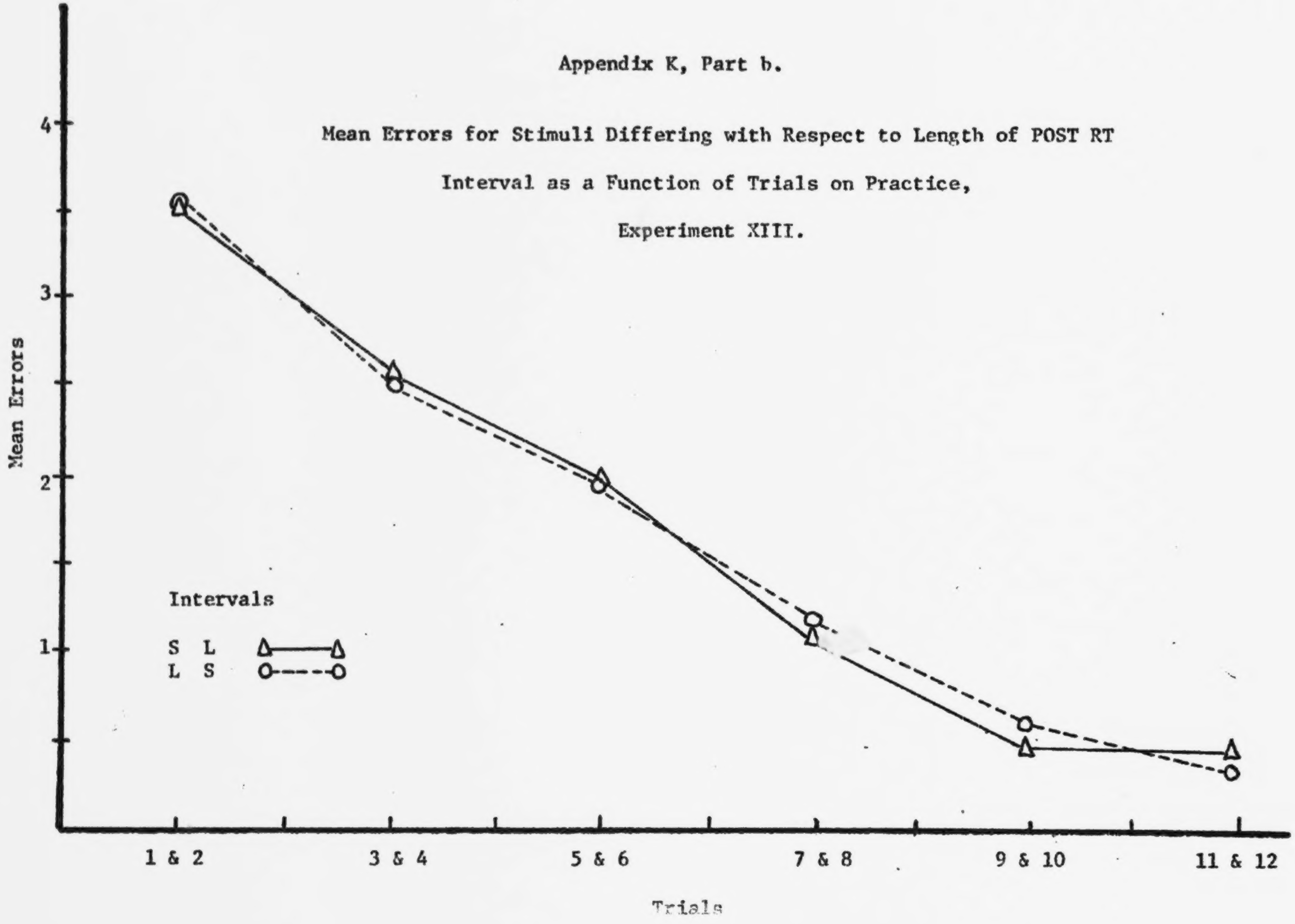
Appendix K, Part a.

Mean Errors for Stimuli Differing with Respect to Length of POST RT Interval as a Function of Trial on Practice, Experiment XIII.



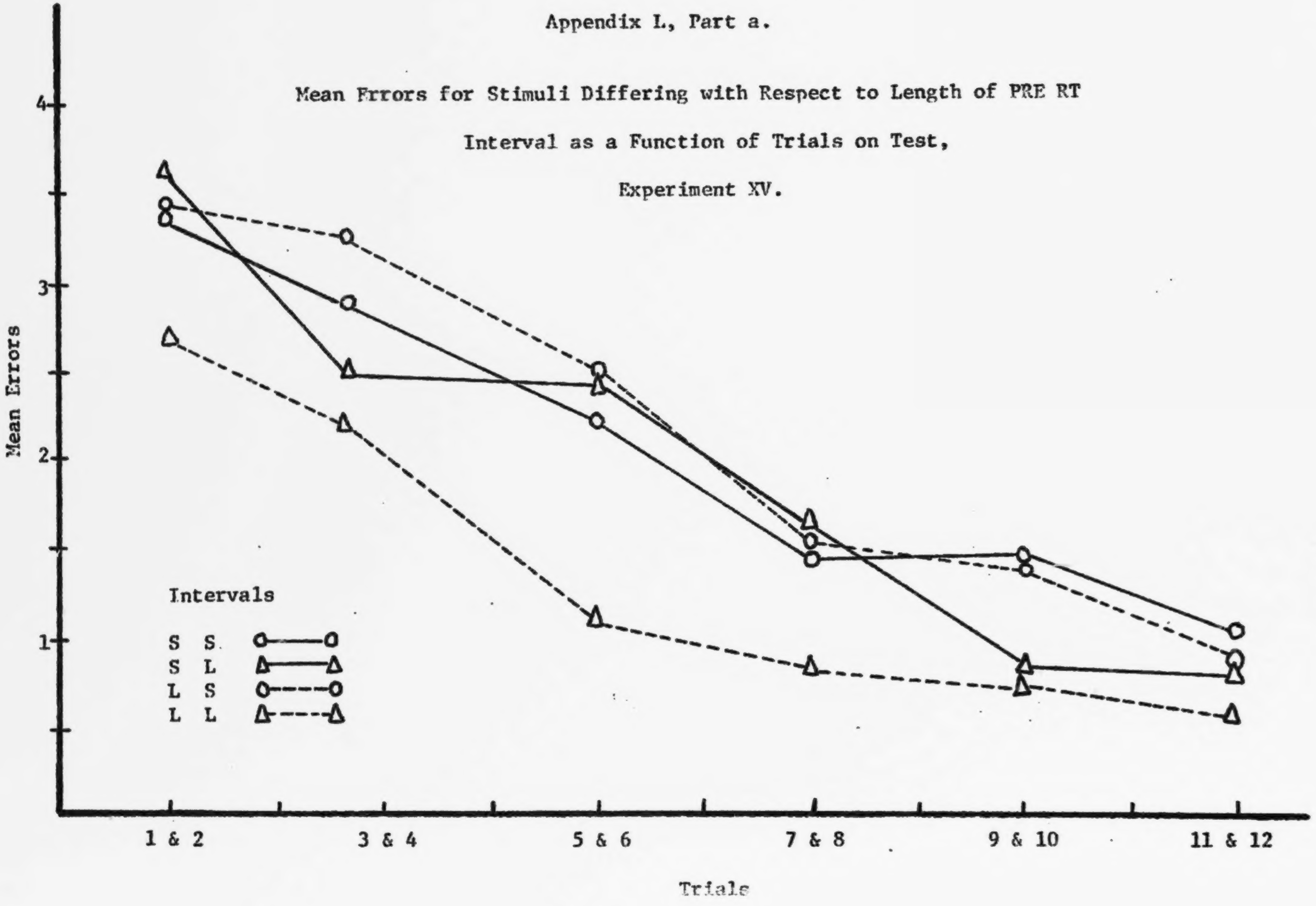
Appendix K, Part b.

Mean Errors for Stimuli Differing with Respect to Length of POST RT Interval as a Function of Trials on Practice, Experiment XIII.



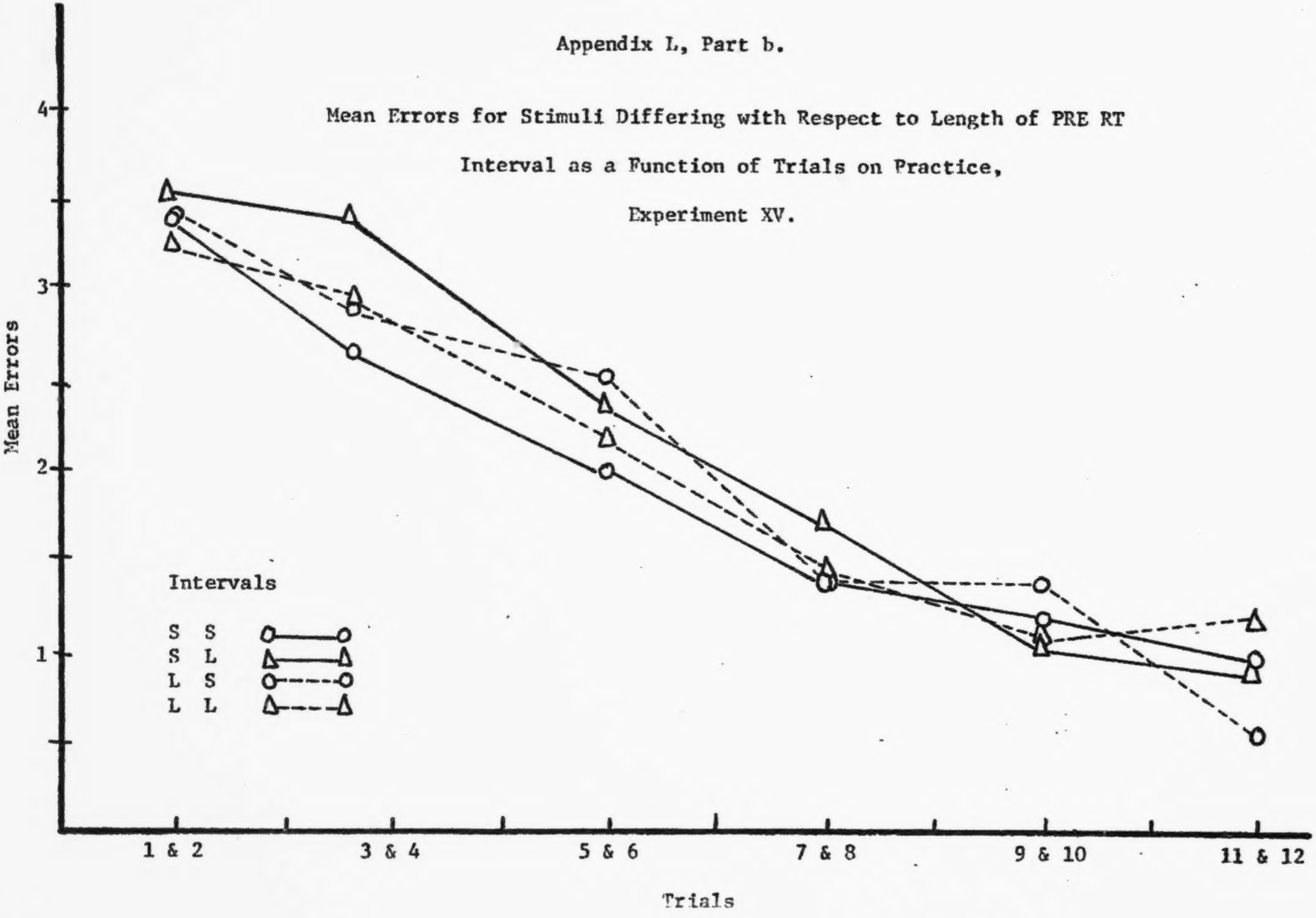
Appendix L, Part a.

Mean Errors for Stimuli Differing with Respect to Length of PRE RT Interval as a Function of Trials on Test, Experiment XV.



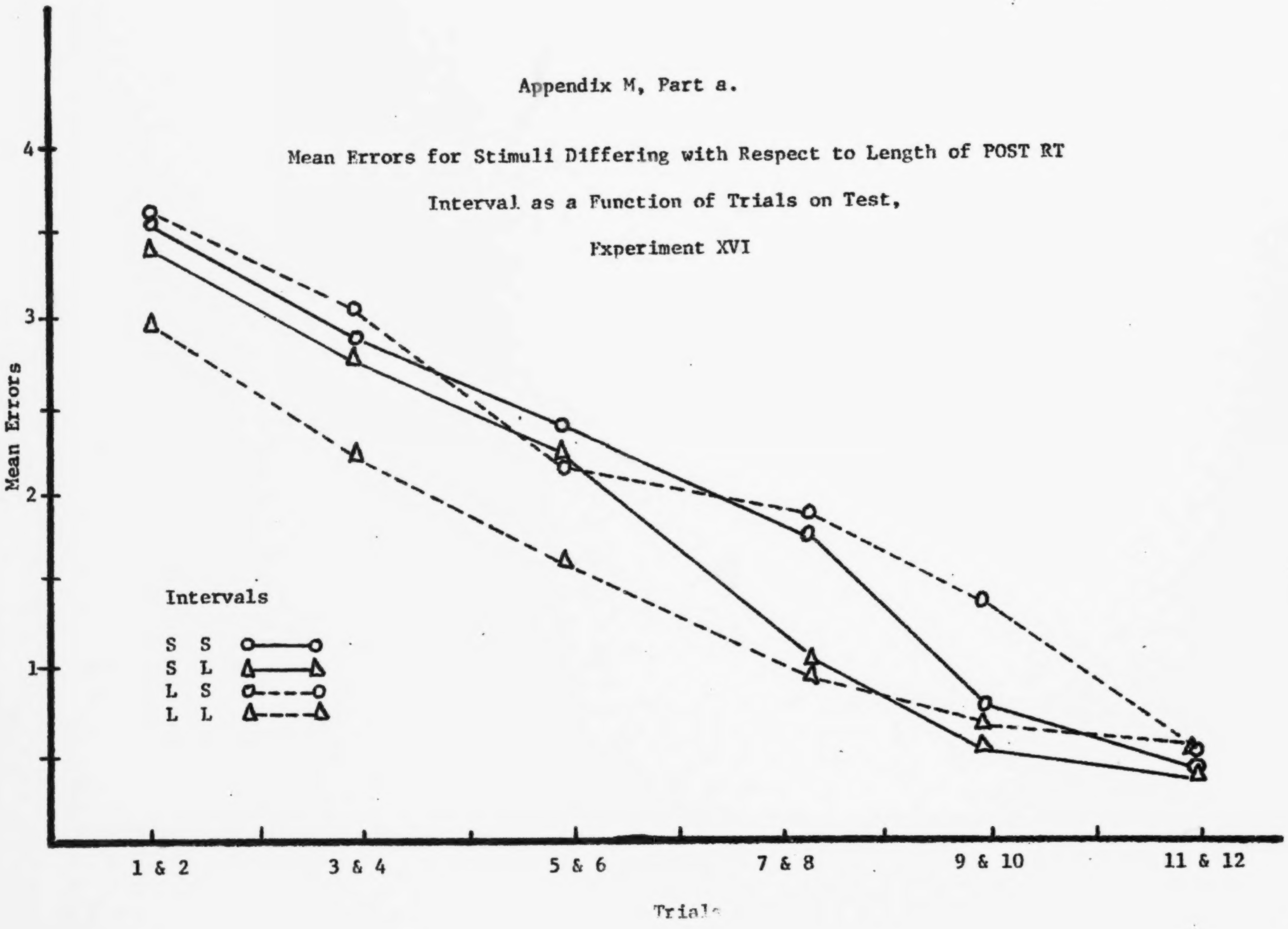
Appendix L, Part b.

Mean Errors for Stimuli Differing with Respect to Length of PRE RT Interval as a Function of Trials on Practice, Experiment XV.



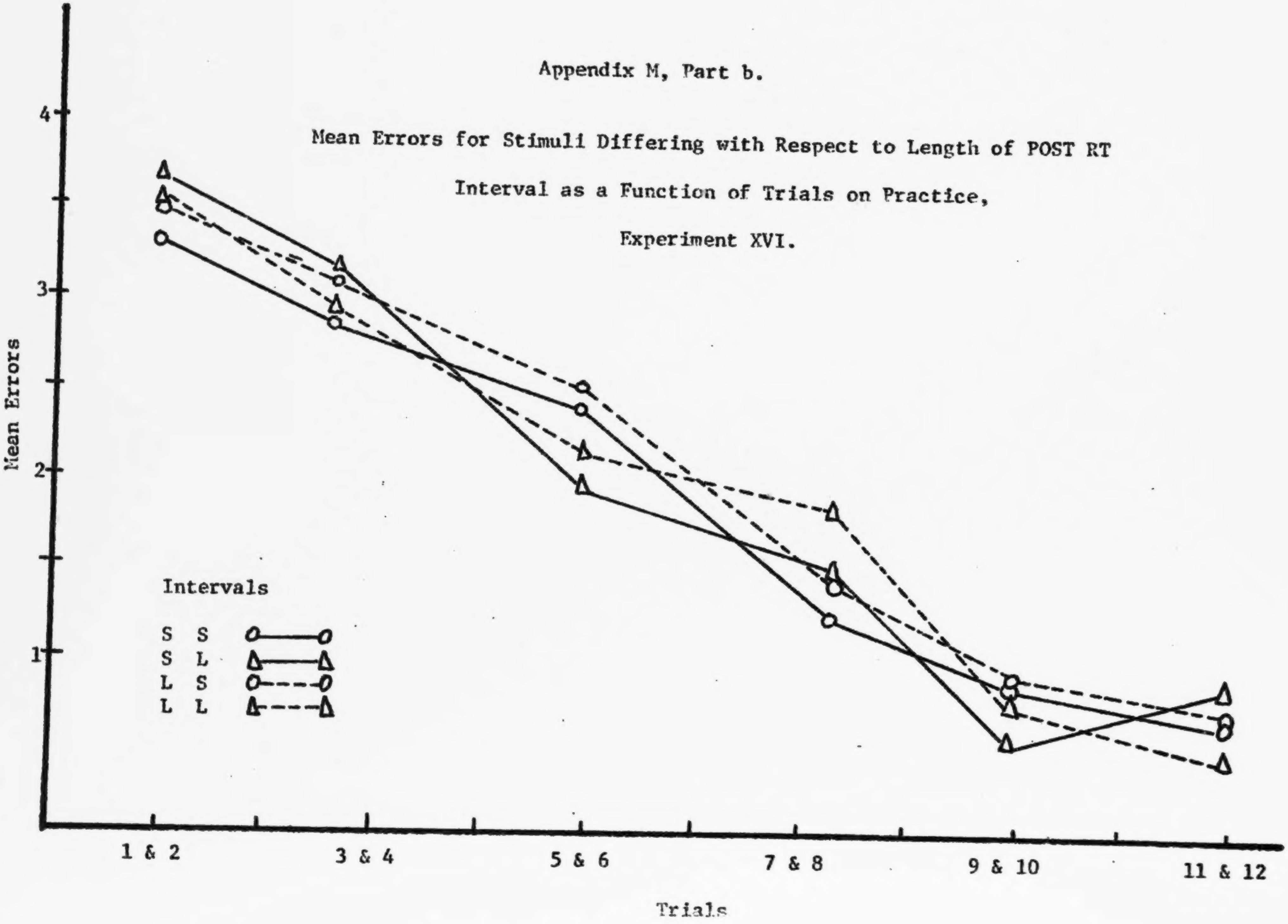
Appendix M, Part a.

Mean Errors for Stimuli Differing with Respect to Length of POST RT Interval as a Function of Trials on Test, Experiment XVI



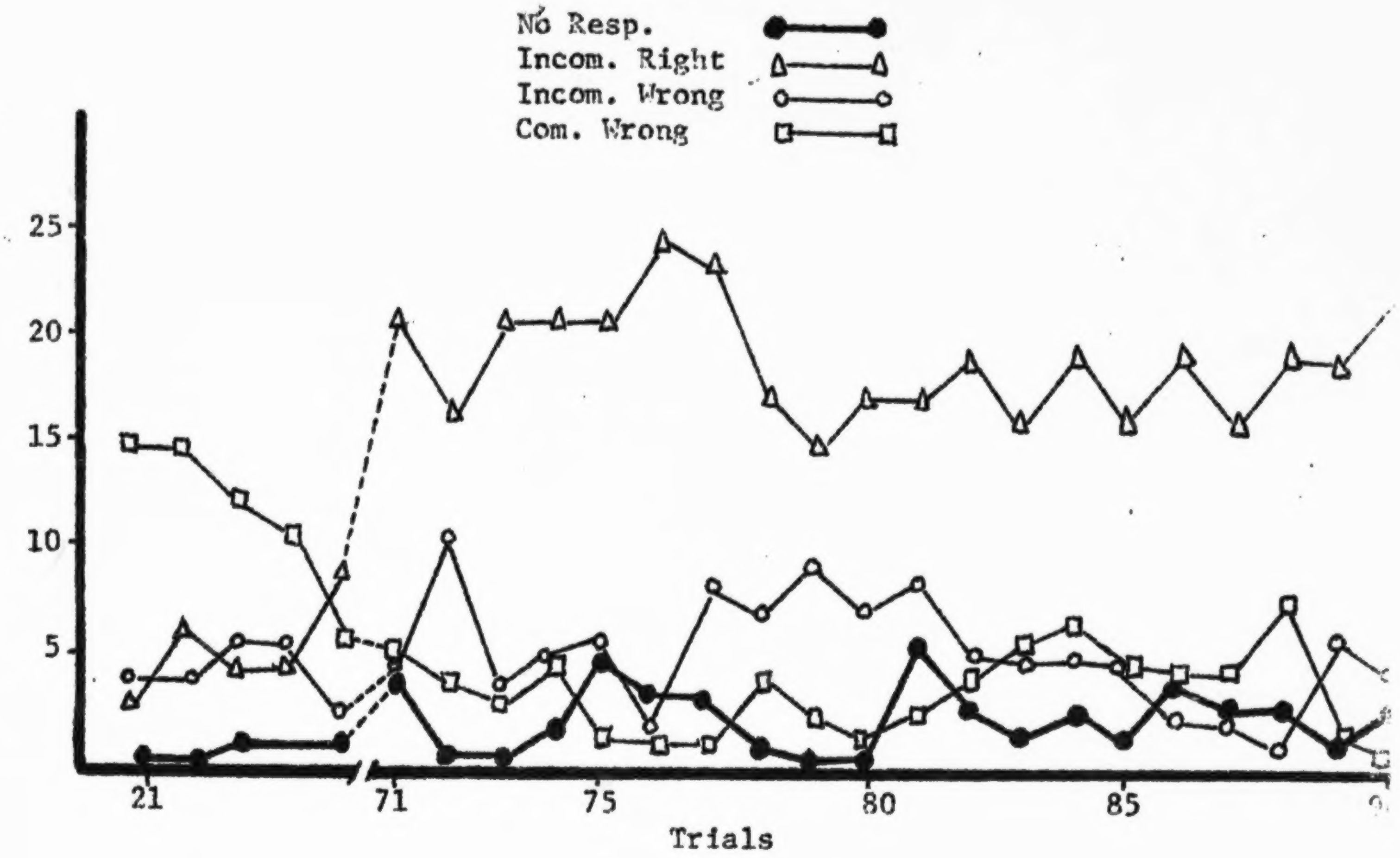
Appendix M, Part b.

Mean Errors for Stimuli Differing with Respect to Length of POST RT Interval as a Function of Trials on Practice, Experiment XVI.

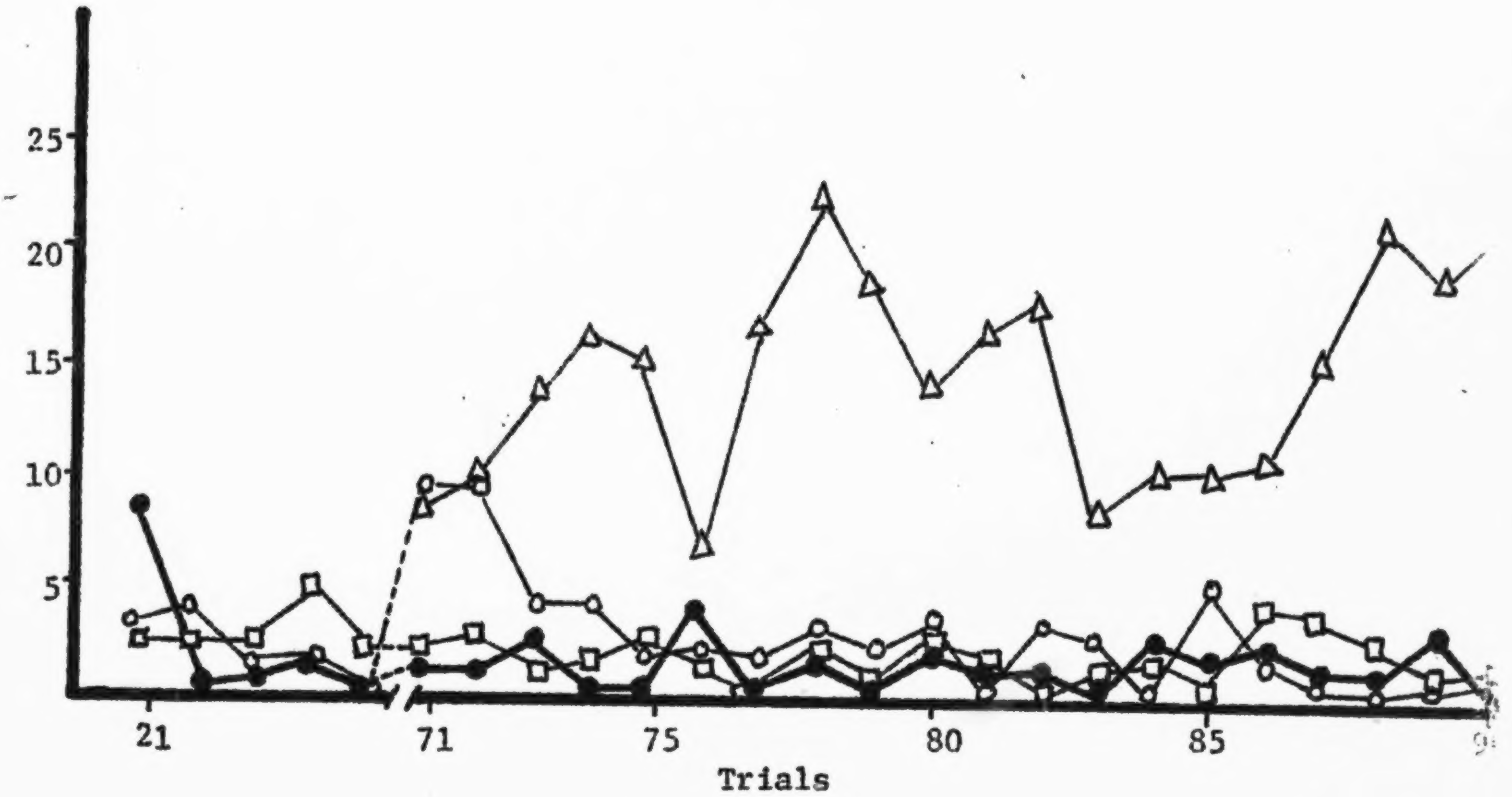


Appendix N

Types of Errors as a Function of Learning Trials for Each of the Experimental Treatments in Exp. XX.



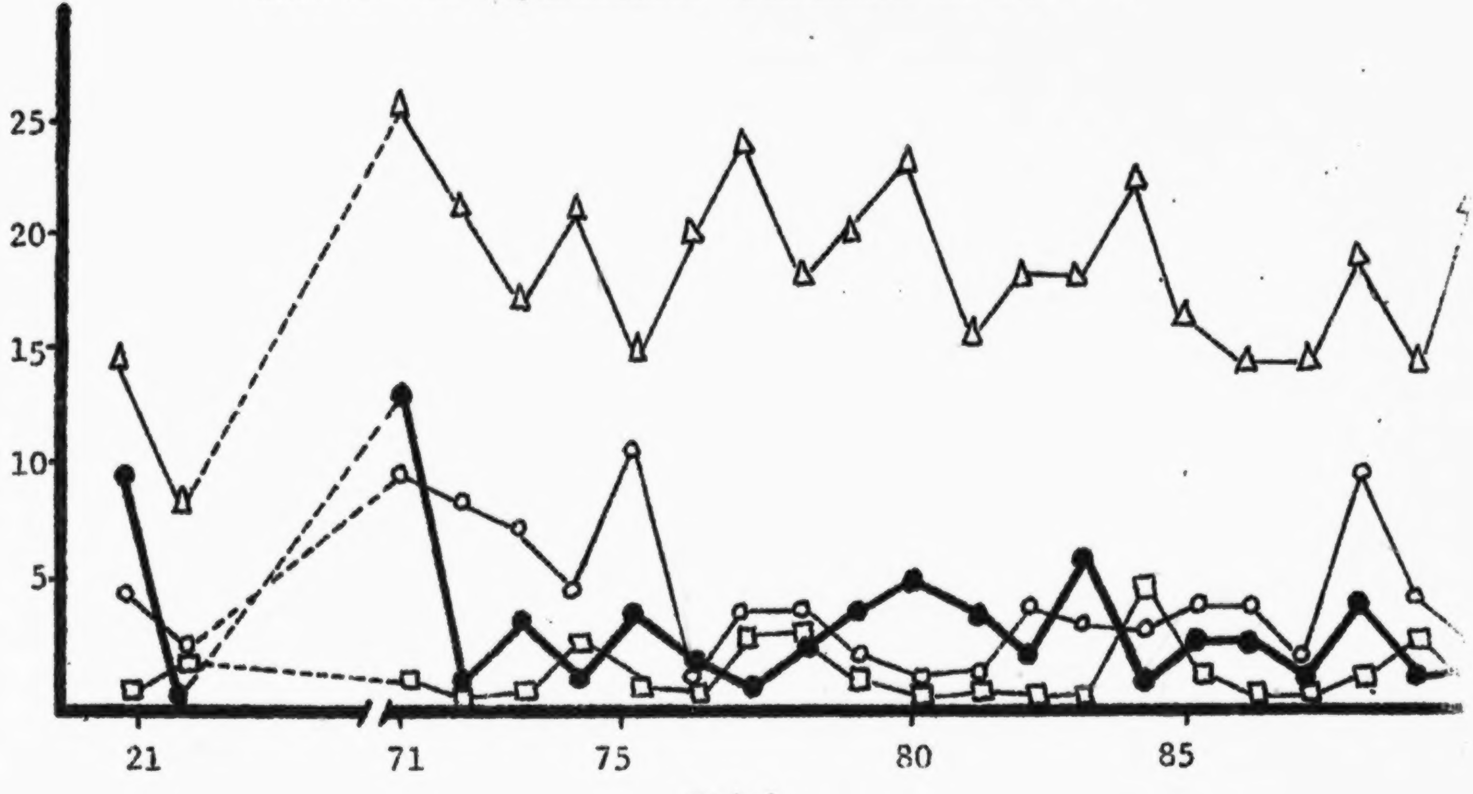
Appendix N, Part a. Experimental Treatment OV 1-90



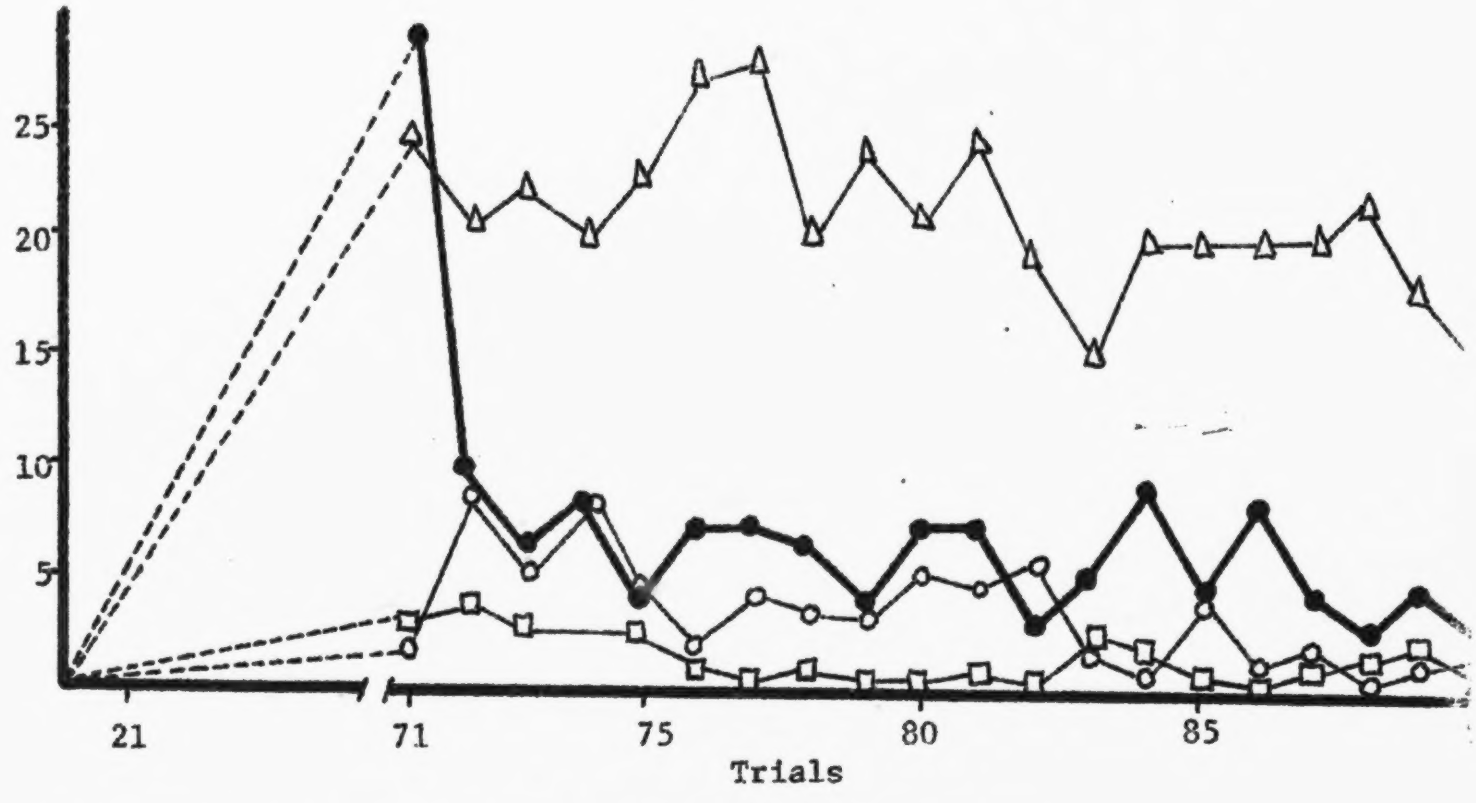
Appendix N, Part b. Experimental Treatment OV 21-90

Appendix N (cont.)

Types of Errors as a Function of Learning Trials for each of the Experimental Treatments in Exp. XX.



Appendix N, Part c. Experimental Treatment OV 21-22, 71-90



Appendix N, Part d. Experimental Treatment OV 71-90